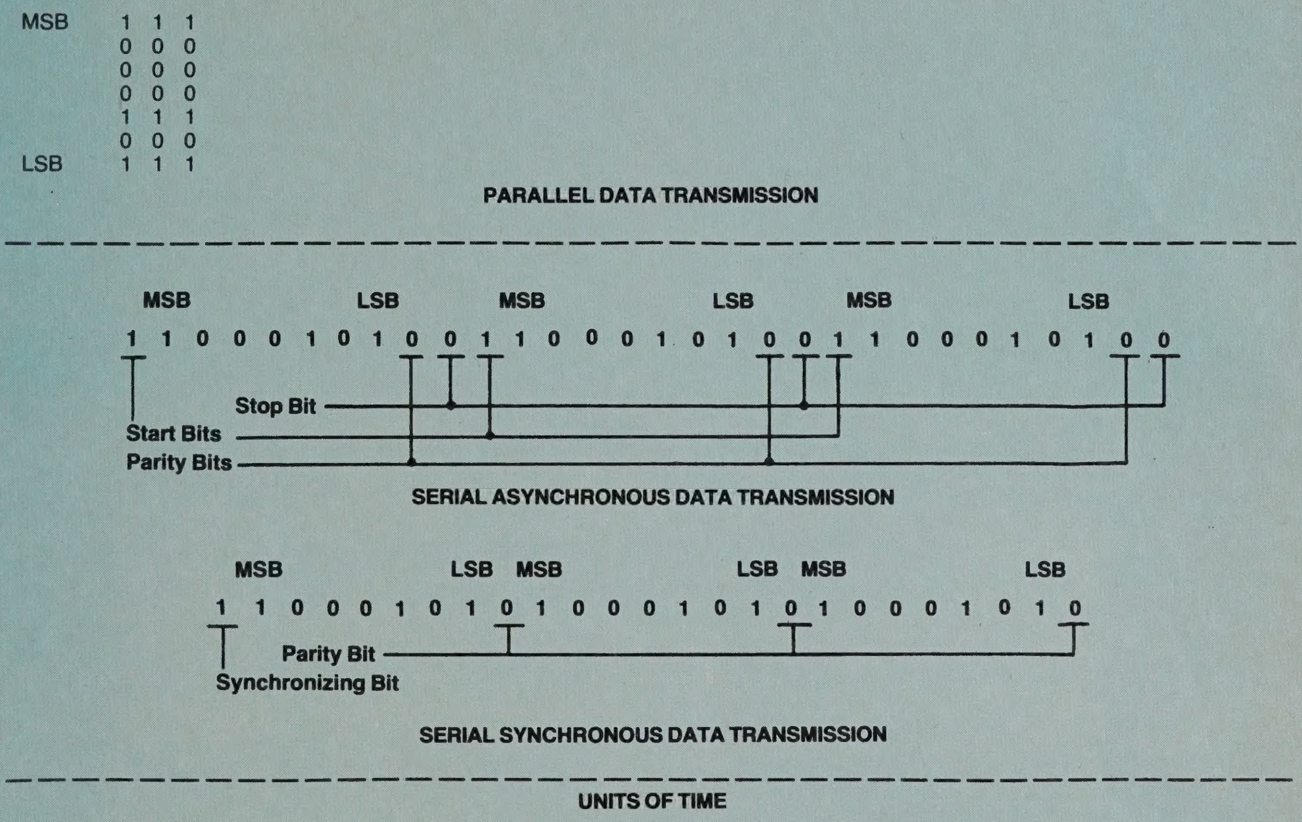
COMPARISONS OF DATA TRANSMISSION TECHNIQUES

The charts below show the relative time for data transmission by 'Parallel', and Asynchronous and Synchronous serial means. The binary designation for the letter "E" as defined in the ASCII specification is used in the example.



As it is quite evident from the above examples, the parallel data transfer is the quickest method to transfer data to a printer, resulting in the most throughput to the printer or other similar device.

correct. Even a computer salesperson will recommend a foreign peripheral if essential to systems needs.

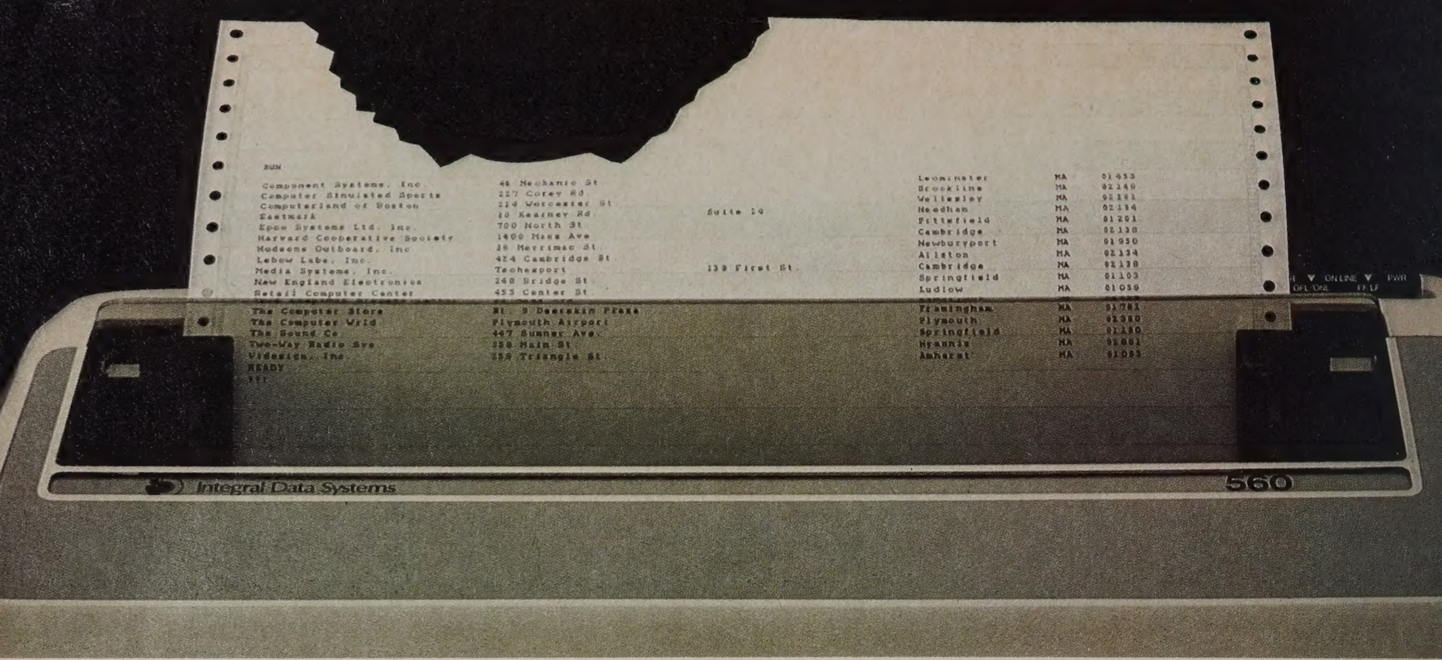
Regardless of reasons for buying a complete subsystem from the computer manufacturer, it's hard to justify their figures. Most computer manufacturers have a limited selection of printers and printer speeds. Therefore, the user may have to settle for less performance than he really wants. And, at the same time, the cost differential is incredible when compared to "independent shopping." For example, one major computer manufacturer offers a 300 lpm printer for its system at $13,500. But the user can easily buy a 600 lpm printer from a number of peripheral manufacturers for $8,000. Add to that a controller from an independent at about $2,000 and the user saves $3,500 to get twice the speed. If the user wants to settle for 300 lpm he can save $6,000 from an independent purchase. If both the printer and controller manufacturers are carefully selected based on reputation and established customer base, the user should have no problem with system support. Meanwhile, he's saved a bundle.

The customer may also choose to buy his complete printer subsystem from a printer manufacturer who offers such subsystems. These companies have, in effect, done the customer's independent shopping for him. The buyer still saves money. In addition he gets support for peripheral and controller from a single source.

One of the special controller features that the buyer must take into consideration is utilization of a printer VFU. A vertical format unit is a memory device that is used to control paper advance to predetermined areas of the page. Not all host software supports a VFU. The potential buyer must be aware of this loose end when selecting a printer from an independent to make sure he gets the options required. At the same time the controller must be configured to operate with VFU, either mechanical or electronic.

Many printers provide graphics capability for printing block characters, bar codes, plotting, and foreign language sets. The controller must have the capability to transmit to these printers the required signals or control codes (preferably under operation of the host computer standard printer/driver routines).

A final controller feature (which the buyer should be aware of) allows operation of the printer by the controller independently from computer software. Many printers have a built-in self-test that can exercise up to 95% of the printer. What still remains unchecked, however, is the actual printer interface (drivers, receivers, connectors) presented to the controlling device. Ability of the printer controller to generate a test pattern, transmit it to the printer and cause the printer to print the pattern takes much of the guess work out of problem identification. Visual indicators on the controller (LEDs) offer additional assistance for troubleshooting and fault isolation. D



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Datacomm glossary penetrates the jargon

Use this listing of datacomm definitions to unravel the technology's specialized vocabulary.

Whether you use it as a reference or an introduction, this compilation of terms will prove a handy guide to datacomm concepts. Adapted with permission from *Data Communications, A User's Guide,* by Ken Sherman (Reston Publishing Co, Reston, VA, 1980), it will help clarify your understanding of a complex and burgeoning field.

ACD (automatic call distributor)—A switching system that automatically distributes incoming calls to a centralized group of receivers in the sequence in which the calls are received. It holds calls until a receiver is available.

AC signaling—Using ac signals or tones to transmit data and/or control signals.

Acoustic coupler—A sound transducer connected to a modem that permits use of a telephone handset as a connection to the telephone-company network for data-transmission purposes.

ACU (automatic calling unit)—A device that automatically places a telephone call upon receiving information from a data-processing device.

Algorithm—A prescribed set of well-defined rules or processes for finding a problem's solution.

Alphanumeric—Consisting of letters and numbers.

Alternate route—A secondary communication path used to reach a destination when the primary one is unavailable.

AM (amplitude modulation)—Transmission of information on a communication line by varying the voltage level (amplitude).

Ambient noise—Interference present in a communication line at all times.

Amplitude variation (ripple)—Unwanted signal-voltage variations at different frequencies on a communication line.

Answer back—A signal from a receiving data-processing device in response to a transmitting one's request indicating that the receiver is ready to accept or has received data.

Application program—A computer program that performs a data-processing function rather than a control operation.

ARQ (automatic retransmission request)—An error-detection and -correction technique that attempts a retry upon detecting an error.

ASCII (American Standard Code for Information Interchange)—A data-communication code set.

ASR—Automatic send/receive.

Asynchronous—Not synchronized by a clocking signal; in code sets, character codes containing start and stop bits.

ATC (automated technical control)—A computer system used to maintain control of a data-communication network.

Attenuation—Loss of communication-signal energy.

Automatic dialer—A device that automatically dials telephone numbers on a network.

AWG (American Wire Gauge)—Wire-size standard.

Backup—The hardware and software resources available to recover after a degradation or failure of one or more system components.

Balanced circuit—A circuit terminated by a network whose impedance balances that of the line, resulting in negligible return losses.

Balancing network—Electronic circuitry used to match 2-wire to 4-wire facilities, sometimes called a hybrid. The balancing is necessary to maximize power transfer and minimize echo.

Bandwidth—The information-carrying capability of a communication line or channel.

Baseband—The frequency band that information-bearing signals occupy before they combine with a carrier in the modulation process.

Base group—Twelve communication-set paths capable of carrying the human voice on a telephone set; a unit of frequency-division-multiplexing systems' bandwidth allocation.

Baud—A data-communication-rate unit used similarly to bits per second (bps) for low-speed data; the number of signal-level changes per second (regardless

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of the information the signals contain).

Baudot—A 5-level code set; its formal name is the International Telegraph Alphabet (ITA) #2.

BCH—An error-detecting and -correcting technique used by communication receivers.

Beam—Microwave radio systems that use ultrahigh or superhigh frequencies (UHF, SHF) to carry communications where the signal is a narrow beam rather than a broadcast signal.

BERT (bit error-rate testing)—Testing a data line with a pattern of bits that are compared before and after a transmission.

Bias—Communication-signal distortion related to bit timing.

Bit rate—The rate at which data bits are transmitted over a communication path, normally expressed in bits per second (bps); not to be confused with the data signaling rate (baud), which measures the rate of signal changes transmitted.

Bit stream—A continuous series of bits transmitted on a line.

Blank—A "no-information" condition in a data-recording medium or storage location. This vacancy can be represented by all spaces or all ZEROs, depending on the medium.

BLERT (block error-rate testing)—Testing a data line with groups of information arranged in transmission blocks.

Block—A set of contiguous bits and/or bytes that make up a definable quantity of information.

Blocking—Describes a condition in a switching system in which no paths or circuits are available to complete a call, resulting in a busy tone returned to the calling party. The term also refers to a denial or busy condition.

Block-multiplexer channel—A computer-peripheral multiplexer channel that interleaves blocks of data. (See **byte-multiplexer channel**; contrast with **selector channel**.)

Bridge—Equipment and techniques used to match circuits to each other, ensuring minimum transmission impairment. Bridging is normally required on multipoint data channels where several local loops or channels interconnect.

Broadband—Refers to transmission facilities whose bandwidth is greater than that available on voice-grade facilities. Also called wide band.

Broadcast—To send messages or communicate simultaneously with many or all points in a circuit.

BSC (Bisync)—An IBM-developed data-link-control procedure using character synchronization.

Buffer—A storage area for a data block.

Burst—A group of events occurring together in time.

Burst error—A series of consecutive errors in data transmission.

Bus—A connective link between multiple processing sites (colocated only), where any of the processing sites can transmit to any other, but only one way at a time.

Byte—A set of contiguous bits constituting a discrete item of information. Most common bytes are six or eight bits long.

Byte-multiplexer channel—A channel that interleaves bytes of data from different sources. (Contrast with **selector channel**.)

Cache memory—A high-speed computer memory that contains the instruction or sequence of instructions most likely to be executed next.

Call-setup time—The overall length of time required to establish a switched call between pieces of data-terminal equipment.

Carrier—An analog signal at a fixed amplitude and frequency that combines with an information-bearing signal in the modulation process to produce an output signal suitable for transmission.

Carrier system—A method of obtaining several channels from one communication path by combining them at the originating end, transmitting a wide-band or high-speed signal and recovering the original information at the receiving end.

CCITT (Consultative Committee for International Telephone and Telegraph)—An international standards group.

CERT (character error-rate testing)—Checking a data line with test characters.

Chain—A series of processing locations through which information must pass on a store-and-forward basis to reach a subsequent location.

Channel—A data-communication path.

Channel bank—Communication equipment that multiplexes, typically used for multiplexing voice-grade channels.

Character—A language unit consisting of bits.

Character parity—Adding an overhead bit to a character code to provide error-checking capability.

Circuit switching—A communication method in which an electrical connection between calling and called stations is established on demand for exclusive circuit use until the connection is released.

Clocking—Time - synchronizing communication information.

Cluster—A group of user terminals colocated and connected to one controller, through which each terminal accesses a communication line.

Coaxial cable—2-conductor wire whose longitudinal axes are coincident; cable with a noise shield around a signal-carrying conductor.

Common mode—A high-speed-modem interface name.

Communication-line controller—A hardware unit that performs line-control functions with a modem.

Compandor—A device used on some telephone channels to improve transmission performance. The equipment compresses the outgoing-speech volume range and expands the incoming volume range on a

long-distance telephone circuit.

Concentrator—An electronic device that interfaces in a store-and-forward mode with multiple low-spe communication lines at a message level and then retransmits those messages to a processing site via one or more high-speed communication lines.

Conditioning—Applying electronic filtering elements to a communication line to improve its ability to support higher transmission data rates. (See **equalization.**)

Connecting block—A cable-termination block where access to circuit connections is available.

Contention—Competition for use of the same communication facilities; a line-control method in which terminals request or bid to transmit.

Control-line timing—Clock signals between a modem and a communication-line controller unit.

CPS (characters per second)—A data-rate unit.

CPU (central processing unit)—The computer control logic used to execute programs.

CRC (cyclic redundancy check)—An error-checking control technique utilizing a binary prime divisor that produces a unique remainder.

Crossbar—A type of widely used control-switching system using a crossbar or coordinate switch. Crossbar switching systems suit data switching because they have low-noise characteristics and can handle Touch-Tone dialing.

CTS (clear to send)—A control signal between a modem and a controller used to initiate data transmission over a communication line.

Cursor—A lighted area on a CRT screen used to indicate the next character location to be accessed.

CXR (carrier)—A communication signal used to indicate the intention to transmit data on a line.

DAA (Data Access Arrangement)—A telephone-switching-system protective device used to attach uncertified nontelephone-company-manufactured equipment to the carrier network.

Data base—A collection of electronically stored data records.

Data compression—A technique that provides for the transmission of fewer data bits than originally required without information loss. The receiving location expands the received data bits into the original bit sequence.

Data set—See **modem.**

Data switcher—A system used to connect network lines to a specific data-processing computer port.

dB (decibel)—Power- and voltage-level-measurement unit.

dBm—Power-level-measurement unit in the telephone industry based on 600Ω impedance and 1004-Hz frequency. 0 dBm is 1 mW at 1004 Hz terminated by 600Ω impedance.

DCE (data-communication equipment)—Equipment (such as a modem) installed at a user's premises that provides all the functions required to establish, maintain and terminate a connection and signal conversion and coding between the data-terminal equipment and the common carrier's line.

DDD (Direct Distance Dial)—The North American telephone dial system.

Dedicated line—A communication line that isn't dialed, also termed a leased or private line.

Delay distortion—Distortion that occurs on communication lines due to signals' different propagation speeds at different frequencies. Measured in microseconds of delay relative to the delay at 1700 Hz. This type of distortion doesn't affect voice communication but can seriously impair data transmissions.

Demodulator—A functional section of a modem that converts received analog line signals to digital form.

Dial up—The use of a rotary-dial or Touch-Tone phone to initiate a station-to-station call.

DMA—Direct memory access from I/O and peripheral controllers without going through the arithmetic processing unit.

DQM (data-quality monitor)—A device used to measure data bias distortion above or below a threshold.

DTE (data-termination equipment)—Equipment that constitutes the data source and/or data sink and provides for the communication control function protocol; it includes any piece of equipment at which a communication path begins or ends.

EBCDIC (Extended Binary Coded Decimal Interchange Code)—An 8-level code set used frequently in data communication.

Echo distortion—A telephone-line impairment caused by electrical reflections at distant points where line impedances are dissimilar.

EIA (Electronic Industries Association) RS-232—The standard interface between a modem and line controller for voice-grade communication lines.

Electronic Switching System (ESS)—A type of telephone switching system that uses a special-purpose digital computer to direct and control the switching operation. ESS permits custom-calling services such as speed dialing, call transfer and 3-way calling.

Encryption—The technique of modifying a known bit stream on a transmission line to make it appear like a random sequence of bits to an unauthorized observer.

Envelope delay—An analog line impairment where a variation of signal delay with frequency occurs across the data-channel bandwidth. (See **delay distortion.**)

Equalization—A technique used to compensate for distortions present on a communication channel. Equalizers add loss or delay to signals in inverse proportion to the channel characteristics. The signal response curve is then relatively "flat" and can be amplified to regain its original form. (See **distortion.**)

F1F2—A type of modem that operates over a half-duplex line (2-wire) to produce two subchannels at two different frequencies for low-speed full-duplex

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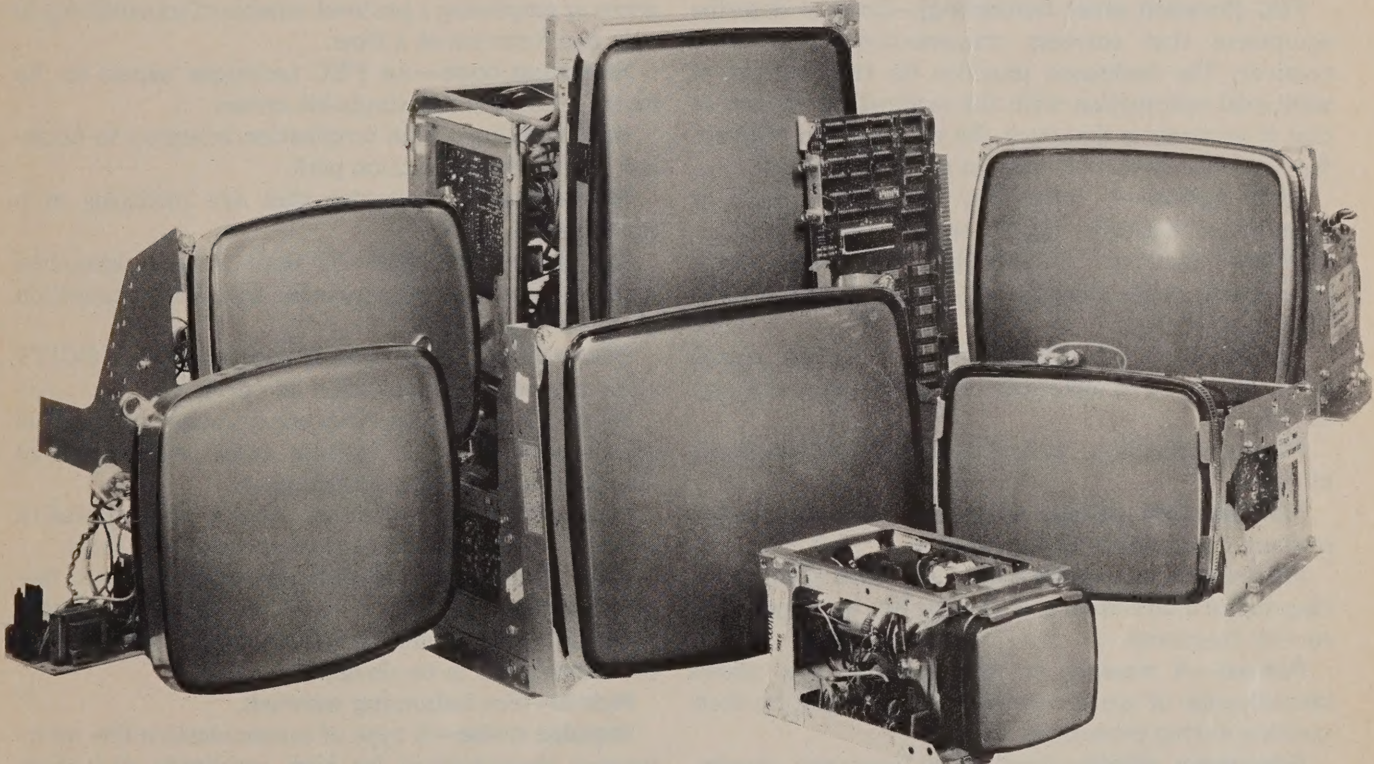

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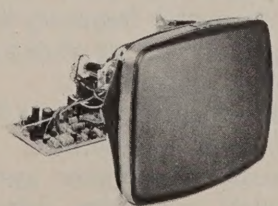

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operation. (See **reverse channel**.)

Facility—A transmission path between two or more locations without terminating or signaling equipment. Adding terminating equipment would produce either a channel, a central-office line or a trunk.

FDM (frequency-division multiplexing)—A technique in which a data line's bandwidth is divided into different frequency subchannels. It permits several terminals to share the same line.

FE (format effectuation)—Characters of a code set used to format information to be sent for processing.

FEC (forward error correcting)—Used to describe equipment that corrects transmission errors at a receiver. The technique provides for transmission of additional information with the original bit stream so that if an error is detected, the receiver can recreate the correct information without a retransmission.

Fiber optics—A technology employing plastic or glass fibers that carry light representing information.

Filter—Electronic circuitry that blocks some signal components while allowing other components to pass through uniformly.

Firmware—A set of software instructions placed permanently or temporarily in a read-only memory (ROM).

Flag—A delimiting bit field used to separate portions of data.

Flexible disk (floppy disk)—A magnetic storage medium constructed of thin plastic.

FM (frequency modulation)—A method of transmitting digital information on an analog line by varying the carrier frequency.

Format—A message or data structure that allows identification of specific control codes or data by their position during processing.

Frequency offset—Analog-line frequency change, an impairment encountered on a communication line.

Frequency shift keying (FSK)—A form of frequency modulation in which the carrier frequency is made to vary or change in frequency precisely when a change in the state of a transmitted signal occurs.

Frequency stacking—Another name for FDM that reveals how the multiplexing is performed.

Front end—An auxiliary computer system that performs network-control operations, releasing the host computer system to process data.

Full duplex (FDX)—A 4-wire circuit or protocol that provides for simultaneous transmission in both directions between two points.

Full/full duplex—A protocol for a multidrop line that permits transmission from a master location to a slave site; the master location can also simultaneously receive a transmission from another slave site on that line.

Gain—The degree to which a signal's amplitude is increased. The amount of amplification realized when a signal passes through an amplifier or repeater, normally measured in decibels.

Gaussian noise—Noise whose amplitude is characterized by the Gaussian distribution, (eg, white noise, ambient noise, hiss).

Group channel—A unit or method of organization on telephone carrier (multiplex) systems. A full group is a channel equivalent to 12 voice-grade channels (48 kHz). A half group has the equivalent bandwidth of six voice-grade channels (24 kHz). When not subdivided into voice facilities, group channels can furnish high-speed data communication.

Guard frequency—Describes the frequencies between subchannels in FDM systems used to guard against subchannel interference.

Half duplex—A communication line consisting of two wires or employing a protocol capable of transmitting in only one direction at a time.

Hamming code—An FEC technique named for its inventor. It corrects single-bit errors.

Handshaking—Line-termination interplay to establish a data-communication path.

Harmonics—Frequencies that are multiples of a fundamental value.

Harmonic distortion—A data-communication-line impairment caused by erroneous frequency generation along the line.

HDLC (High Level Data-Link Control)—A CCITT standard data-communication line protocol.

Hit on the line—Describes errors caused by external interference, such as impulse noise resulting from lightning or man-made interference.

House cables—Conductors inside a building used to connect communication equipment to outside lines.

HRC (horizontal redundancy checking)—A validity-checking technique used on data-transmission blocks in which redundant information is included with the information to be checked.

Hybrid—See **balancing network.**

Impulse noise—A type of communication-line interference characterized by high amplitude and short duration.

Insertion loss—Signal-power loss resulting from connecting communication equipment with dissimilar impedance values.

Interference—Refers to unwanted occurrences on communication channels that result from natural or man-made noises and signals.

Intermodulation distortion—An analog-line impairment where two frequencies interact to create an erroneous frequency, which in turn distorts the data-signal representation.

ITDM (intelligent time-division multiplexer)—A multiplexer that assigns time slots on demand rather than on a fixed subchannel-scanning basis. Also termed a statistical multiplexer.

Jitter—Type of analog-communication-line distortion caused by a signal's variation from its reference timing position, which can cause data-transmission errors, particularly at high speeds. This variation can be in

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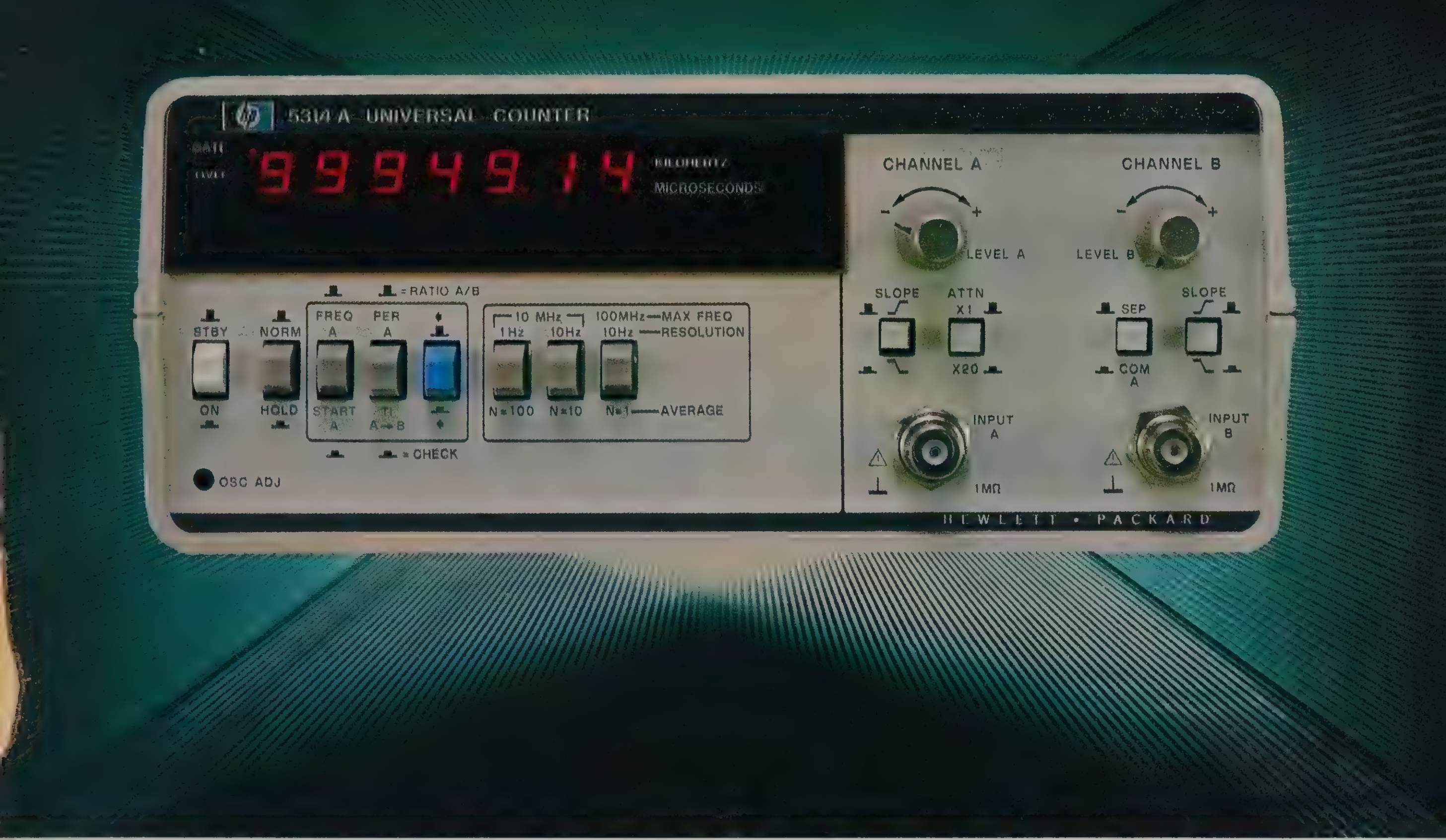

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amplitude, time, frequency or phase.

Jumbo group—The highest FDM carrier-system multiplexing level; it contains 3600 voice-frequency (VF) or telephone channels (six master groups).

Leased line (private line, dedicated line)—A communication line for voice and/or data rented from a communication carrier.

Line protocol—A control program used to perform data-communication functions over network lines. Consists of both handshaking and line-control functions that move the data between transmit and receive locations.

Local loop—The access line from either a user terminal or a computer port to the first telephone office along the line path.

Logging—Recording data, such as error events or transactions, for future reference.

Long line—A communication line spanning a long distance relative to the local loop.

Loop current—A teletypewriter-to-line interface and operating technique that doesn't employ modems.

Loopback—Directing signals back toward the source at some point along a communication path.

LTS (line test set)—Analog-line test unit.

Main distribution frame (MDF)—The cable rack on which all distribution and trunk cables leading into a central office are terminated.

Message switching—Routing messages between three or more locations by store-and-forward techniques in a computer.

MG (master group)—An FDM carrier-multiplexing level containing 600 voice-frequency channels.

Microcode—A set of software instructions that execute a macro instruction.

MIL-188—A military interface between a modem and line controller equivalent to RS-232.

Modem (data set)—An acronym for a unit that *mo*dulates and *dem*odulates digital information from a terminal or computer port to an analog carrier signal for passage over an analog line.

Multiplexed line—A data-communication line equipped with multiplexers at each end.

Multipoint line—A communication line with several subsidiary controllers sharing time on the line under a central site's control.

Noise—A communication-line impairment inherent in the line design or induced by transient energy bursts.

On line—A direct connection between a remote terminal and a central processing site.

Open wire—Communication lines that aren't insulated and formed into cables, but are instead mounted on aerial crossarms on utility poles.

Packet-mode terminal—Data-terminal equipment that can control and format packets and transmit and receive them.

Packet switching—The transfer of data by means of addressed packets whereby interim point-to-point channels are available only during the transmission of one packet. The channel then becomes available for the transfer of packets from the same or other messages. Contrast with circuit switching, where the data network determines the end-to-end routing before the entire message transfer.

PAD (packet assembler/disassembler)—Equipment providing packet assembly and disassembly facilities.

Parity error—An error occurring when the results of the parity calculations at the transmit and receive ends of a system don't agree.

Passband filters—Filters used in modem design to allow only the frequencies within the communication channel to pass while rejecting all frequencies outside the channel.

PC (phase corrector)—A part of synchronous modems that adjusts the local data-clocking signal to match the incoming receive data sent by the remote clocking signal.

Phase jitter—An analog-line impairment caused by power and communication equipment along the line that shifts the signal phase relationship back and forth.

PM (phase modulation)—Variation of an analog signal's phase in direct relationship to digital input information.

Point-to-point—A communication line connected directly from one site to another.

Polling—A control message sent from a master site to a slave site that serves as an invitation to transmit data to the master site.

Primary center—A Class 3 telephone-switching office at the next level above toll center.

Privacy—The techniques used for limiting and/or preventing access to specific system information from otherwise authorized system users.

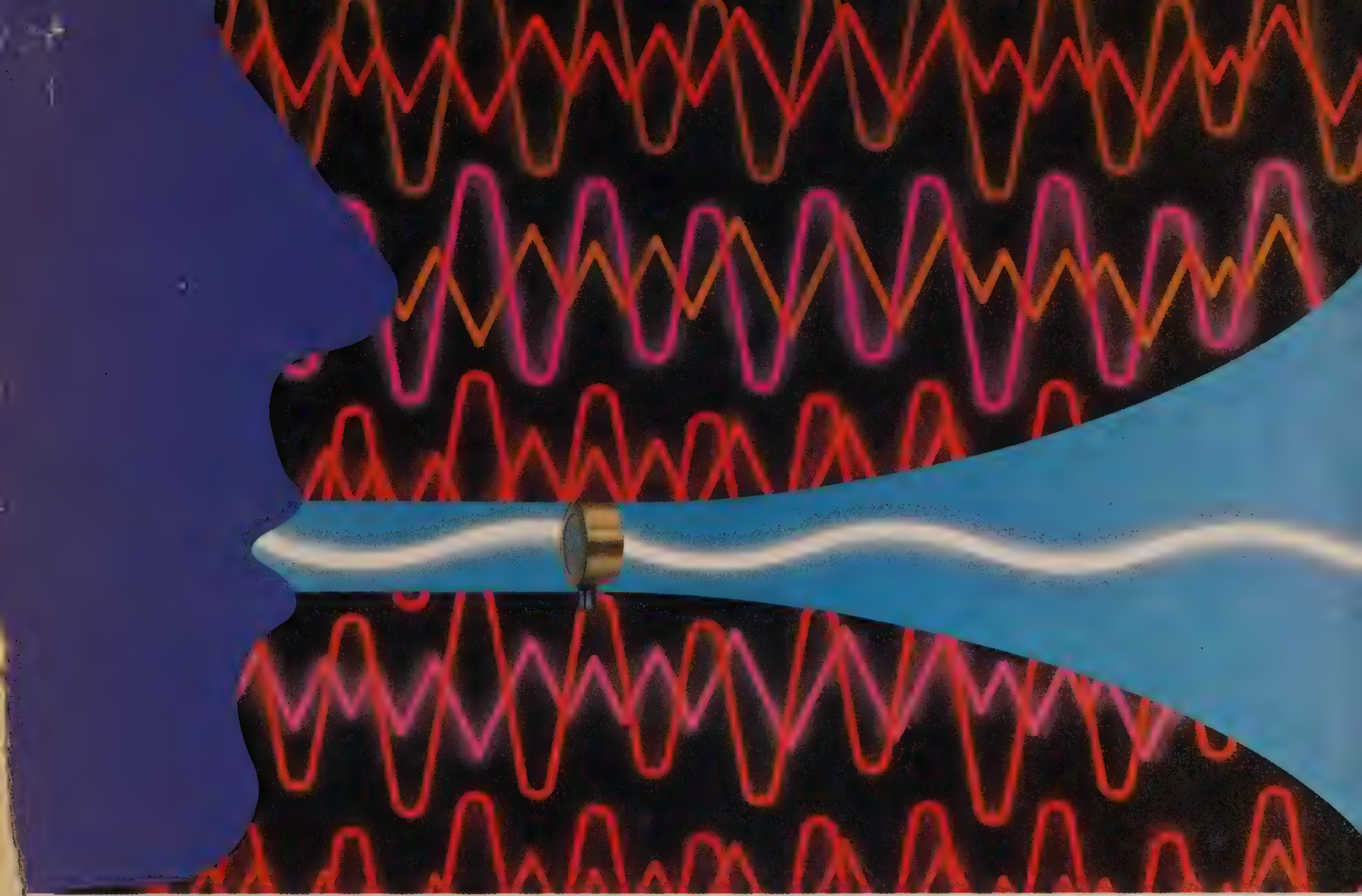
Propagation delay—The time necessary for a signal to travel from one point in a circuit to another.

Protocol—A formal set of conventions governing the format and control of inputs and outputs between two communicating processes, including handshaking and line discipline.

Pulse modulation—Modulating the characteristics of a pulse series in one of several ways to create an information-bearing signal. Typical methods involve modifying the pulses' amplitude (PAM), width or duration (PDM), or position (PPM). The most common pulse-modulation technique employed in telephone communications is pulse-code modulation (PCM), in which the system samples the information signals at regular intervals and transmits a series of pulses in coded form, representing the amplitude of the information signal at the sampling time.

Quadrature distortion—Analog-signal distortion frequently found in phase-modulation modems.

Reactance—Frequency-sensitive communication-line impairment causing loss of power and phase



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Overall frequency response, shown by the chart, cuts off distant sounds at the lower frequencies where most background noise exists. Near field (1/4″) response is flat throughout the spectrum occupied by human speech.

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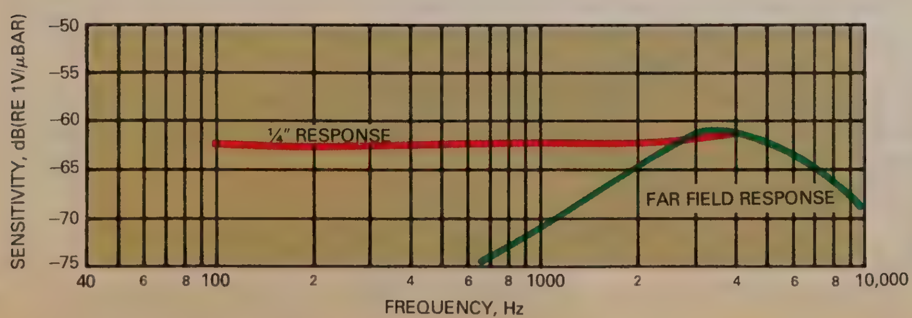

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shifting.

Recovery—The actions required to bring a system to a predefined level of operation after a degradation or failure.

Regional center—A Class 1 telephone-switching office, the top level in the DDD system.

Response time—The time measured from the depression of a terminal's Enter key to the display of the first character of the response at that terminal site.

Reverse channel—An optional feature on some modems that provides simultaneous communication from the receiver to the transmitter on a 2-wire channel. It can be used for message transmission, circuit assurance or breaking and to facilitate certain forms of error control and network diagnostics. Also termed backward channel.

RTS (request to send)—An RS-232 control signal between a modem and user's digital equipment that initiates the data-transmission sequence on a communication line.

SDLC (Synchronous Data-Link Control)—An IBM data-communication message protocol.

Sectional center—A Class 2 telephone-switching office between a regional and a primary center.

Selector channel—A channel designed to operate with only one I/O device at a time. Once the I/O device is selected, a complete record transfers one byte at a time. (Contrast with **block-multiplexer channel**.)

Slicing level—A voltage or current level of a digital signal at which a ONE or ZERO can be determined.

Slot—A unit of time in a TDM frame during which a subchannel bit or character is carried to the other end of the circuit and extracted by the receiving TDM unit.

S/N (signal-to-noise) ratio—The relative power levels of a signal and noise on a communication line, expressed in decibels.

SRC (spiral redundancy checking)—A validity-checking technique for transmission blocks where the redundant information sent with the block for receiver checking is accumulated in a spiral-bit-position fashion.

Store and forward—A data-communication technique that accepts messages or transactions, stores them until they are validated and complete and then forwards them to the next location as addressed in the message or transaction header.

Streaming—A modem's condition when it is sending a carrier signal on a multidrop communication line and hasn't been polled.

Super group—The assembly of five 12-channel groups, for simultaneous modulation and demodulation, occupying adjacent bands in the spectrum. Can be used as 60 voice-grade or wide-band channels or combinations of both.

SYN (SYNC)—A bit or character used to synchronize a time frame in a time-division multiplexer. Also, a sequence used by synchronous modems to perform bit synchronization and by the line controller for character synchronization.

Synchronous modem—A line-termination unit that uses a derived clocking signal to perform bit synchronization with incoming data.

TDM (time-division multiplexing)—A data-communication technique for combining several lower speed channels into one facility or transmission path at a higher speed in which each low-speed channel is allotted a specific position in the signal stream based upon time. Thus, the information on the low-speed input channels is interleaved at higher speed on the multiplexed channel. At the receiver, the signals are separated to reconstruct the individual low-speed channels.

Telemetry—Transmission and collection of data obtained by sensing conditions in a real-time environment.

Text—The part of a message or transaction between the control information of the header and that of the trace section or tail that constitutes the information to be processed or delivered to the addressed location.

Thermal noise—A type of electromagnetic noise produced in conductors or in electronic circuitry that is proportional to temperature. (See **Gaussian noise**.)

Time sharing—A processing technique that permits multiple users to share resources simultaneously.

Toll center—A Class 4 telephone-switching office up one level from the end or serving office, named for the call-billing apparatus found there.

T/P (transaction processing)—A processing technique using on-line control programs and a remote terminal network so that inquiries and applications against a data base can be performed at any processing site where the data is stored. Routing is performed based on the content of the message that also contains the information to be processed.

Turnaround time—The time required for a modem to reverse the direction of transmission on a half-duplex line.

Uncontrolled terminal—A user terminal that is on line all the time and does not contain line-control logic for polling and calling.

VF (voice frequency)—Describes a telephone channel designed to carry the human voice.

VHF (very high frequency)—A radio carrier-frequency band (30 to 300 MHz) used in emergency situations for telephone and data communications.

VRC (vertical redundancy checking)—A method of character parity checking.

White noise—See **Gaussian noise** and **thermal noise.**

Wide band—Implies data speeds requiring the equivalent of more than one VF channel for operation; broadband. **EDN**

Article Interest Quotient (Circle One)
High 479 *Medium* 480 *Low* 481

11111111 = 1111 1111

[illegible]$_{16}$ $= 15 \times 16^{0} + 15 \times 16^{1}$

$= 15 \times 1 + 240$

$= 15 + 240$

$= 255_{10}$

Conversion Chart

decimal	octal	hexadecimal	binary
0	0	0	0000 0000
1	1	1	0000 0001
2	2	2	0000 0010
3	3	3	0000 0011
4	4	4	0000 0100
5	5	5	0000 0101
[illegible]	6	6	0000 0110
[illegible]	7	7	0000 0111
[illegible]	10	8	0000 1000
[illegible]	11	9	0000 1001
10	12	A	0000 1010
11	13	[illegible]	0000 1011
12	14	[illegible]	0000 1100
13	15	[illegible]	0000 1101
14	16	[illegible]	0000 1110
[illegible]	[illegible]	[illegible]	0000 1111
16	20	10	0001 0000
17	21	11	0001 0001
1	22	12	0001 0010
19	[illegible]	13	0001 0011
[illegible]	[illegible]	14	0001 0100
21	25	15	0001 0101

22	26	16	0001 0110
23	27	17	0001 0111
24	30	18	0001 1000
25	31	19	0001 1001
26	32	1A	0001 1010
27	33	1B	0001 1011
28	34	1C	0001 1100
29	35	1D	0001 1101
30	36	1E	0001 1110
31	37	1F	0001 1111
32	40	20	0010 0000
33	41	21	0010 0001
34	42	22	0010 0010
35	43	23	0010 0011
36	44	24	0010 0100
37	45	25	0010 0101
38	46	26	0010 0110
39	47	27	0010 0111
40	50	28	0010 1000

some Universal Rules

WHEN YOU NEED A RULE . . .

1. MURPHY'S LAW: If anything can go wrong, it will.
2. O'TOOLE'S COMMENTARY ON MURPHY'S LAW: Murphy was an optimist.
3. THE UNSPEAKABLE LAW: As soon as you mention something, if it's good, it goes away, if it's bad, it happens.
4. NONRECIPROCAL LAWS OF EXPECTATIONS: Negative expectations yield negative results. Positive expectations yield negative results.
5. HOWE'S LAW: Every man has a scheme that will not work.
6. ZYMURGY'S FIRST LAW OF EVOLVING SYSTEMS DYNAMICS: Once you open a can of worms, the only way to recan them is to use a larger can.
7. ETORRE'S OBSERVATION: The other line moves faster.
8. SKINNER'S CONSTANT (FLANNAGAN'S FINAGLING FACTOR): That quantity which, when multiplied by, divided by, added to or subtracted from the answer you get, gives you the answer you should have gotten.
9. LAW OF SELECTIVE GRAVITY: An object will fall so as to do the most damage.

   JENNING'S COROLLARY: The chance of the bread falling with the buttered side down is directly proportional to the cost of the carpet.
10. GORDON'S FIRST LAW: If a research project is not worth doing, it is not worth doing well.
11. MAIER'S LAW: If the facts do not conform to the theory, they must be disposed of.
12. HOARE'S LAW OF LARGER PROBLEMS: Inside every large problem is a small problem struggling to get out.
13. BOREN'S FIRST LAW: When in doubt, mumble.
14. THE GOLDEN RULE OF ARTS AND SCIENCES: Whoever has the gold makes the rule.
15. BARTH'S DISTINCTION: There are two types of people: those who divide people into two types, and those who do not.
16. SEGAL'S LAW: A man with one watch knows what time it is. A man with two watches is never sure.
17. NINETY-NINETY RULE OF PROJECT SCHEDULES: The first 90 percent of the project takes 90 percent of the time, and the last 10 percent takes the other 90 percent.
18. FARBER'S FOURTH LAW: Necessity is the mother of strange bedfellows.

METRIC

some Universal Numbers

MM	Frac.	Inches	MM	Frac.	Inches	MM	Frac.	Inches	MM	Frac.	Inches
.01		.0004	8.3344	21/64	.3281	21.4312	27/32	.8437	57		2.244
.02		.0008	8.7312	11/32	.3437	21.8281	55/64	.8594	58		2.283
.03		.0012	**9.000**		.3543	**22.000**		.8661	59		2.323
.04		.0016	9.1281	23/64	.3594	22.2250	**7/8**	**.875**	**60**		2.362
.05		.0020	9.525	**3/8**	**.375**	22.6219	57/64	.8906	61		2.402
.06		.0024	9.9219	25/64	.3906	**23.000**		.9055	62		2.441
.07		.0028	**10.000**		.3937	23.0187	29/32	.9062	63		2.480
.08		.0032	10.3187	13/32	.4062	23.4156	59/64	.9219	64		2.520
.09		.0035	10.7156	27/64	.4219	23.8125	15/16	.9375	**65**		2.559
.10		.004	**11.000**		.4331	**24.000**		.9449	66		2.598
.20		.008	11.1125	7/16	.4375	24.2094	61/64	.9531	67		2.638
.30		.012	11.5094	29/64	.4531	24.6062	31/32	.9687	68		2.677
.3969	**1/64**	**.0156**	11.9062	15/32	.4687	**25.000**		.9843	69		2.717
.40		.0158	**12.000**		.4724	25.0031	63/64	.9844	**70**		2.756
.50		.0197	12.3031	31/64	.4844	25.400	**1"**	**1.000**	71		2.795
.60		.0236	12.700	**1/2**	**.500**	26		1.024	72		2.835
.70		.0276	**13.000**		.5118	27	1-1/16	1.063	73		2.874
.7937	**1/32**	**.0312**	13.0968	33/64	.5156	28		1.102	74		2.913
.80		.0315	13.4937	17/32	.5312	29		1.142	**75**	2-61/64	2.953
.90		.0354	13.8906	35/64	.5469	**30**		1.181	76		2.992
1.000		.0394	**14.000**		.5512	31		1.220	77	3-1/32	3.031
1.1906	3/64	.0469	14.2875	**9/16**	**.5625**	32		1.260	78		3.071
1.5875	**1/16**	**.0625**	14.6844	37/64	.5781	33		1.299	79		3.110
1.9844	5/64	.0781	**15.000**		.5906	34		1.339	**80**		3.150
2.000		.0787	15.0312	19/32	.5937	**35**		1.378	81		3.189
2.3812	3/32	.0937	15.4781	39/64	.6094	36		1.417	82		3.228
2.7781	7/64	.1094	15.875	**5/8**	**.625**	37		1.457	83		3.268
3.000		.1181	**16.000**		.6299	38		1.496	84		3.307
3.175	**1/8**	**.125**	16.2719	41/64	.6406	39		1.535	**85**		3.346
3.5719	9/64	.1406	16.6687	21/32	.6562	**40**		1.575	86		3.386
3.9687	5/32	.1562	**17.000**		.6693	41		1.614	87		3.425
4.000		.1575	17.0656	43/64	.6719	42		1.654	88		3.465
4.3656	11/64	.1719	17.4625	11/16	.6875	43		1.693	89		3.504
4.7625	**3/16**	**.1875**	17.8594	45/64	.7031	44		1.732	**90**		3.543
5.000		.1969	**18.000**		.7087	**45**		1.772	91		3.583
5.1594	13/64	.2031	18.2562	23/32	.7187	46		1.811	92		3.622
5.5562	7/32	.2187	18.6532	47/64	.7344	47		1.850	93		3.661
5.9531	15/64	.2344	**19.000**		.748	48	1-57/64	1.890	94		3.701
6.000		.2362	19.050	**3/4**	**.750**	49		1.929	**95**		3.740
6.3500	**1/4**	**.250**	19.4469	49/64	.7656	**50**		1.969	96		3.780
6.7469	17/64	.2656	19.8433	25/32	.7812	51		2.008	97		3.819
7.000		.2756	**20.000**		.7874	52		2.047	98		3.858
7.1437	9/32	.2812	20.2402	51/64	.7969	53		2.087	99		3.898
7.5406	19/64	.2969	20.6375	13/16	.8125	54		2.126	**100**	3-15/16	3.937
7.9375	**5/16**	**.3125**	**21.000**		.8268	**55**		2.165			
8.000		.315	21.0344	53/64	.8281	56		2.205			

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Phone-jack choice affects modem performance

The FCC specifies jacks for modem connection to the public switched telephone network. Although all of these jacks effectively implement the modem connection, system performance depends on how well the jack matches your system's needs.

Jack L Douglass, *Universal Data Systems*

When you're installing a modem for data communication over the public switched telephone network, consider the tradeoffs between using standard jacks and the more sophisticated jacks that the telephone company offers. Both types of jacks are registered and specified by the FCC under Part 68 of its Rules and Regulations. An overview of the most commonly used registered jacks and typical modem-connection schemes using both standard and special telephones will help you select the proper jack.

Registered jacks are available in two types: permissive jacks and data jacks. The permissive jack allows the modem to transmit at a maximum signal level of −9 dBm, but it provides no guarantees concerning the signal level that's received at the telephone company's central office. The optimum input-signal level at the central office is −12 dBm, and the normal loss on a phone line between a customer and the central office is 3 to 6 dB. Thus, for a permissive jack, the input-signal level at the central office will be between −12 and −15 dBm.

The permissive-jack configuration is sufficient for most modem applications. The RJ11C jack—usually found in the home or office—is the most common permissive-jack arrangement. A 6-pin, modular jack for single-line, bridged tip-and-ring service, it typically has only two wires connected—the tip and the ring **(Fig 1)**. Other 6-pin modular permissive jacks (eg, the RJ12C, RJ13C, and RJ16C) also use the RJ11C housing. A

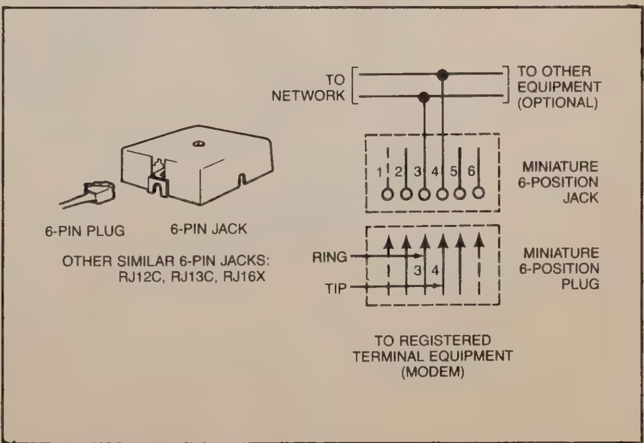

***Fig 1—The most common permissive jack arrangement,** the RJ11C, is usually found in the home or office. It typically has only two wires connected—the tip and the ring.*

special permissive arrangement, the RJ16X, allows you to use exclusion-key telephones.

Among the drawbacks of the permissive-jack arrangement is its lack of guarantees on such parameters as peak-to-average ratio, attenuation distortion, envelope-delay distortion, line loss, and signal-to-noise ratio. If you're dissatisfied with the quality of the phone line in terms of its data-transmission capabilities, you'll get little sympathy from the telephone company—in its view, these are voice-grade lines; if you can talk on them, the lines are within specification. If your application won't tolerate the phone-line characteristics of a permissive-jack arrangement, you might need a data jack.

Data jacks, which provide a means of adjusting the central office's signal receive level, use one of two techniques: programmable and fixed-loss loop. The programmable arrangement uses a resistor inside the jack to establish the modem output-signal level. The phone company measures the local loop loss when the jack is installed and then selects a resistor to ensure that the received signal at the central office is −12 dBm—the optimum value. Part 68 of the FCC Rules includes a list of resistance values appropriate for implementing automatic control of signal output power, so the phone company can adjust for the optimum power level before you connect the modem.

In the fixed-loss loop arrangement, on the other hand, the modem output level is fixed at a signal level of −4 dBm. An adjustable attenuator in series with the modem output serves to compensate for local loop loss of the telephone line. When the jack is installed, the attenuator is set to develop an optimum power level of −12 dBm at the central office.

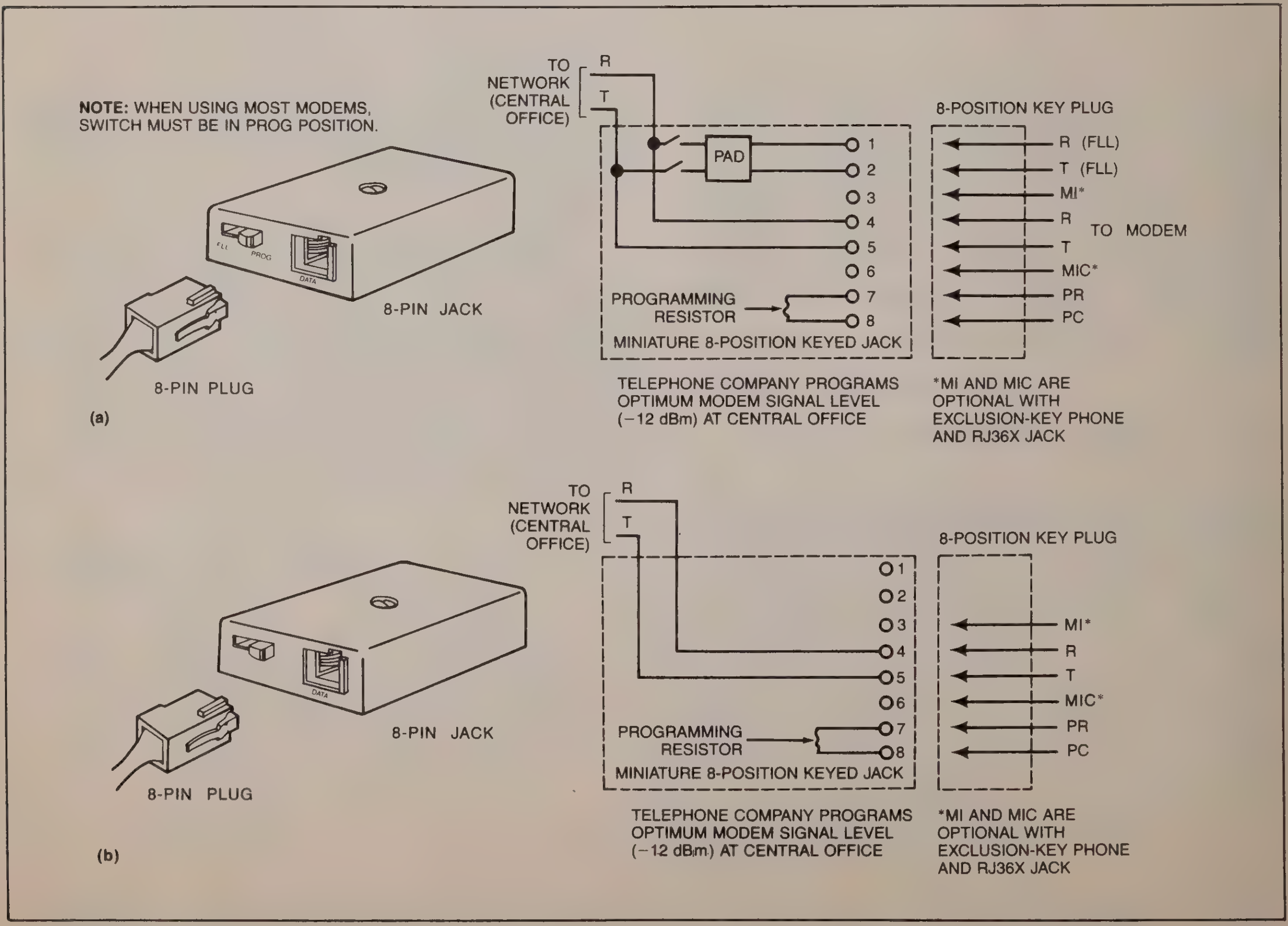

Fig 2—Adjustable output level *is a key feature of data jacks. There are two data jack categories: the universal configuration* ***(a)*** *and the programmed configuration* ***(b)***.

Data jacks provide a means of adjusting the signal level received at the telephone company's central office.

Data jacks are available in two configurations: the universal configuration, RJ41S **(Fig 2a)**, and the programmed configuration, RJ45S **(Fig 2b)**. The RJ41S incorporates a resistor for programmed signal level (designated PROG on the jack) and an attenuator for fixed-loss-loop transmit-signal level (designated FLL on the jack). You select the appropriate mode of operation via a switch.

Most modems operate with both the RJ41S and the RJ45S jacks. With the RJ41S, however, keep the switch in the PROG position. With the switch in the FLL position, the receive and transmit signals are both attenuated, and this may increase error rate because of the lower signal-to-noise ratio.

As stated earlier, for many typical applications that require a modem, the less sophisticated RJ11C permissive jack is adequate. To connect an RJ11C jack to a typical modem **(Fig 3a)**, you'll need an 8- to 6-pin modular cable to run between the modem's 8-pin phone-company (TELCO) jack and the 6-pin RJ11C jack on the wall. Next, using the 6- to 6-pin cable that comes with the telephone, you connect the telephone (standard rotary or Touchtone) to the telephone-set (TELSET) jack on the rear of the modem. A talk/data switch on the modem's front panel serves to connect the telephone line to either the modem or the telephone. If you want the modem to answer calls automatically, the switch must be in the data position.

A typical modem-to-data-jack interconnection **(Fig 3b)** follows the same sequence as that of the permissive jack. In the data-jack case, however, you'll need an 8- to 8-pin modular cable between the jack (RJ41S or RJ45S) and the modem. If you're using an RJ41S jack, make sure the switch is in the PROG position. As before, the telephone will connect to the telephone-set jack at the rear of the modem; set the talk/data switch on the modem to the data position for automatic answering.

Although the interconnection of standard telephones (both rotary and Touchtone) is relatively straightforward, another type of instrument—the exclusion-key telephone, which offers more than just the on and off modes of operation—presents a new set of problems. Exclusion-key telephones serve such applications as those that require the phone to be located remote from the modem, such as in a secure area, and applications that require aural monitoring of the modem's audio signal.

Exclusion-key phones have a white switch-hook button on the left side of the cradle. Two control leads, called mode indication (MI/A) and mode indication common (MIC/A1), connect to the switch. Exclusion-key telephones are available in two configurations: the DSCL (data set controls the telephone line) and the TSCL (telephone set controls the telephone line). The TSCL configuration is normally used with a manual-answer data-access arrangement and seldom with direct-connect modems. The DSCL configuration, however, is used with direct-connect modems.

Data set controls operation

In the DSCL configuration, you have three options for operating the phone: handset in the cradle, handset off the cradle with the exclusion key in the middle position, and handset off the cradle with the exclusion key in the up position. With the handset in the cradle, the tip-and-ring leads pass through the telephone to the modem, and MI/A and MIC/A1 are open. In this case, incoming calls route directly to the modem.

When the handset is off the cradle and the exclusion key is in the middle position, the tip-and-ring leads pass through the modem. The MI/A and MIC/A1 leads are open; when the telephone has the aural-monitoring option, tip and ring are bridged to the phone's earpiece through a capacitor. You can thus monitor the modem's audio signal.

With the handset off the cradle and the exclusion key in the up position, the tip-and-ring leads connect to the handset instead of the modem. Because the leads connect to the handset, you can place and answer calls manually. When the exclusion key is up, the MI/A and MIC/A1 leads are shorted, signaling the modem that the telephone is in voice mode. When you place the handset in the cradle after terminating a call, the MI/A and MIC/A1 leads open, causing the modem to go off hook and connect to the telephone line. Exclusion-key telephone operation is identical for permissive- and data-type jacks.

If you're using an exclusion-key phone, you'll need an 8- to 6-pin modular cable to connect a typical modem to a permissive RJ16X jack **(Fig 4a)**. Normally, this setup will not use the telephone-set jack on the rear of the modem. Instead, you'll connect the exclusion-key phone to an 8-pin RJ36X jack using a cable the telephone company supplies. The telephone company will also interconnect the RJ16X and RJ36X jacks. The modem's talk/data switch should be in the data position when the modem is originating or answering calls. A line-powered modem will not operate with an exclusion-key telephone.

For data jacks **(Fig 4b)**, on the other hand, you'll

Exclusion-key telephones serve applications requiring aural monitoring, or situations where the phone is located some distance from the modem.

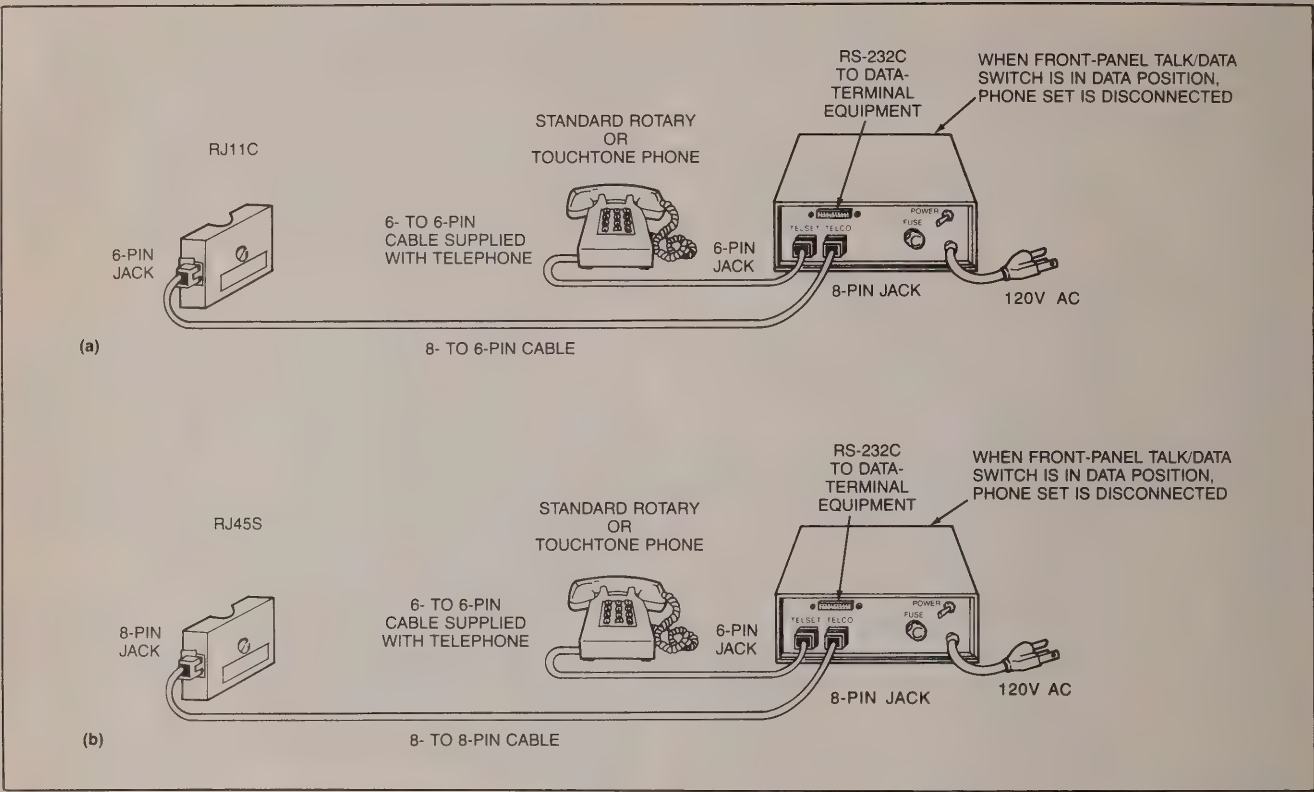

Fig 3—To connect a permissive jack to a modem, *you'll need an 8- to 6-pin modular cable* ***(a)****. A typical modem-to-data-jack interconnect* ***(b)*** *is quite similar but uses an 8- to 8-pin cable.*

need an 8- to 8-pin modular cable to connect the modem to the RJ41S or RJ45S jack on the wall. If you're using an RJ41S, be sure to place the switch in the PROG position. Again, you won't normally use the telephone-set jack on the rear of the modem. The phone company, which will provide a cable for connecting the exclusion-key telephone to an 8-pin RJ36X jack, will interconnect the RJ36X and data jack (RJ41S or RJ45S). As before, the modem's talk/data switch should be in the data (normal) position when the modem is originating or answering calls.

Selecting the proper telephone line jack

Armed with the foregoing details of typical jack arrangements and modem configurations, you can select the telephone-line jack that best serves your application. To do so, don't forget to consider your application and the quality of phone line it requires. If your application requires high-quality lines—if, for example, the modem is to be used in a computer center, you're working with a high-speed (greater than 2400-bps) modem, or you're located in a remote area where the quality of the lines is generally poor—consider ordering an RJ41S or RJ45S data jack. On the other hand, if your modem operates at lower speeds, if you're located in a metropolitan area close to the telephone company's central office, or if you're a home-computer user with just one modem, you'll likely find a permissive RJ11C jack arrangement satisfactory.

In addition, don't forget to consider the complexity of special (nonstandard) modem/telephone configurations, if they apply to your application. In most cases, these special configurations are expensive and unnecessary, and they complicate the interconnection task. Although some modems accommodate only the special configurations, others offer the capability as an option. Before you buy a modem, determine whether it interconnects only with special telephone equipment or whether you can use it with less expensive standard devices.

If your application does, however, require more than the ordinary modem-to-telephone-company interconnection—eg, if you must connect the modem to a private branch exchange (PBX), digital branch exchange (DBX), or a multiline-key telephone set—you

To select the optimum phone jack, you must evaluate your system needs.

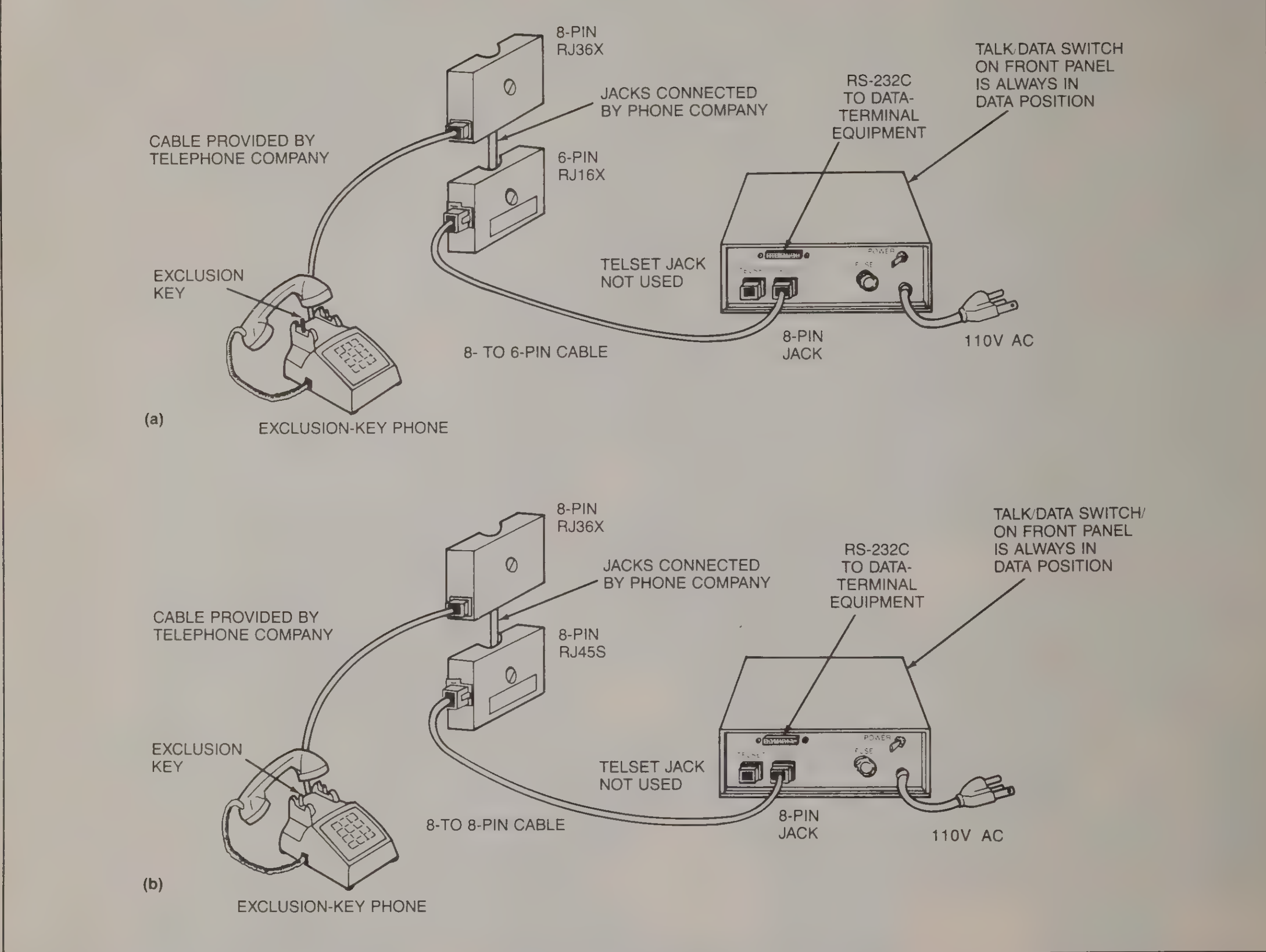

Fig 4—Working with exclusion-key telephones, *the modem-to-permissive-jack interconnect* ***(a)*** *will normally use an RJ36X jack instead of the telephone-set jack on the rear of the modem. In a data-jack interconnect scheme* ***(b)****, make sure the switch on the RJ41S jack is in the PROG position.*

face additional interconnection problems. The two solutions to these problems involve additional expense.

Modems will work with most types of analog PBXs, but you must use a permissive-jack arrangement, the quality of which might be inadequate for your application. DBX applications, on the other hand, are somewhat more complicated because of the lack of standardization in the DBX market; the problems you experience will vary from manufacturer to manufacturer. Some DBXs, for example, use a low sampling rate on the coder/decoder, and the low sampling rate increases the modem's error rate. Other DBXs use nonstandard tones and ringing signals. As a result, some autodial modems dial incorrect numbers and autoanswer modems might not answer calls. A final problem with DBXs involves their digital interface; most modems require an analog interface.

Interconnecting a modem to a multiline-key telephone presents other problems. Most modems don't have the ability to control the A and A1 leads, which indicate when the line is occupied. In addition, multiline-key telephones also suffer from a lack of standardization. Several jack manufacturers make adapters for these phones, but the adapters don't necessarily work with every modem on the market.

Fortunately, two reliable techniques exist to help you solve the PBX, DBX, or multiline-key phone modem-interconnect problem. The best solution is to order a

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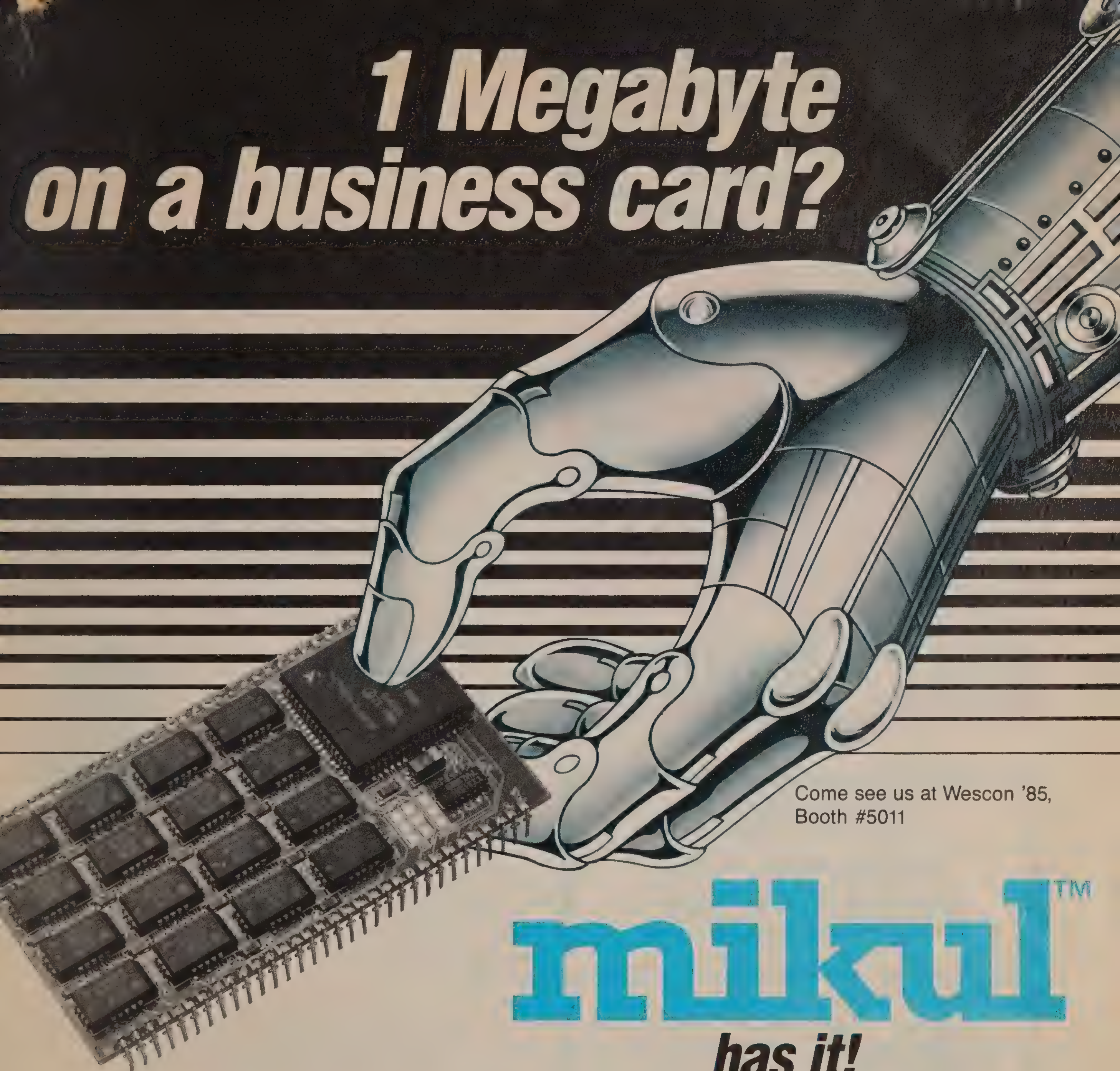

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CIRCLE NO 251

separate line for the modem—one that's not associated with the PBX, DBX, or multiline-key telephone. Unfortunately, this technique involves additional cost.

Second, you can let the telephone company install a transfer key—a switch that allows you to select modem or normal operation. In the modem position, the telephone line from the central office goes directly to the modem. The normal position, on the other hand, routes the line from the central office into the PBX, DBX, or multiline-key telephone. Although this second remedy also involves additional cost, it is a one-time cost as opposed to the monthly charge you would incur by leasing another line. **EDN**

Author's biography

Jack L Douglass is manager of applications engineering at Universal Data Systems (Huntsville, AL), where he has worked for eight years. He conducts seminars on data communications, provides field and sales support of products, and is involved in product evaluations. He holds a BSEE from the University of Alabama, is a member of the EIA TR30.3 subcommittee, and has written two books on data communications. Jack's hobbies include oil painting, color-print processing, hunting, fishing, cave exploring, and programming on a home computer.

Article Interest Quotient (Circle One)
High 485 Medium 486 Low 487

1.5 MODEM TERMINOLOGY

Acoustic Coupler: A device that permits the use of a telephone handset as a connection to dial-up telephone lines (rather than a direct connection using a DAA interface) for data transmission by means of sound transducers. Usually implemented for call origination.

Aliasing: Aliasing occurs when high frequency noise, which is close or higher in frequency to the sampling clock frequency, is "mixed down" (difference frequency) into the frequency band of the received carrier signal (applicable to sampled data). The TMS99532A and TMS99534A have antialiasing filters in both the receive and transmit paths.

Analog Loopback Mode: A diagnostic mode whereby the transmitted analog output is internally connected to the analog receiver input so that the chip's entire signal path is under test.

Analog Receiver: The analog receiver accepts the audio signals on the telephone line as an input, determines if the received signal represents a logic one (mark) or a logic zero (space) and outputs the digital result.

Analog Transmitter: The modem transmitter accepts serial data for an input, uses it to modulate an oscillator between two audio frequencies and then transmits the resulting analog signal over the telephone line to the remote receiver.

Audible Ringing Tone: A local loop signal for supervisory purposes from the Central Office (CO) to the calling telephone to indicate that the called phone is ringing.

Answer Tone: A tone returned by the answering modem to the originating modem and the network.

Asynchronous Transmission: A data transmission scheme that handles data on a character-by-character basis without synchronization (a clocking signal). The character code includes a "start" bit to identify the beginning of a data character, a "stop" bit to identify the end of the data character and a "parity" bit to check for errors in transmission.

Attenuation: Decrease of a communication signal's energy during transmission.

Audio Frequencies: Frequencies in the range of human hearing, i.e., 30 to 20,000 cycles per second.

Automatic Calling Unit (ACU): A device that is used to automatically dial a telephone number.

Bandpass Filter: A circuit that outputs a signal band of frequencies.

Bandwidth: The frequency range or information-carrying capability of a communications channel. Conventional dial-up telephone lines have a total bandwidth of 300 to 3300 Hz (voice-grade).

Baseband: Digital information that is to be modulated onto the carrier (analog) signal for transmission over the telephone line.

Bias (Asymmetrical) Distortion: Distortion affecting a binary (mark, space) modulation scheme whereby the actual mark or space has a longer or shorter duration than the corresponding theoretical duration. The TMS99532A and TMS99534A have built-in mark biasing to compensate for the natural space biasing of the telephone lines.

Bit Error Rate (BER): A measurement of the average number of bits transmitted before an error occurs. Usually expressed as the reciprocal of the average.

Bit Rate (BPS) versus Baud Rate: For modems using voice-grade telephone lines, the bit rate equals the data rate. The baud rate is the actual number of times per second that the transmitted carrier is modulated or changes state. Each modulation may represent multiple bits.

Carrier: An analog signal fixed in amplitude and frequency that can be combined in a modulation process with a second information-bearing signal to produce a signal for transmission.

CCITT (International Telegraph and Telephone Consultative Committee): An international forum for communication system standards.

Central Office (CO): The telephone company's switching station that first switches the telephone lines into the network.

Channel: A one-way communications path.

C-Message Weighting: The Bell System standard weighting network for the evaluation of noise effects on voice-grade data services. Used in bit error rate testing.

Communication Mode: Operational characteristic of a modem relating to reception and transmission. A system may have the following options: simplex, half-duplex and full-duplex operation. The TMS99532A and TMS99534A have pin settings for call answering, call origination, analog loopback testing and answer tone enable so that the desired communications function may be implemented.

Coupling (To The Telephone Line): Due to technical and safety reasons, it is required to couple the signals to and from the telephone line using a transformer. The transformer provides DC isolation between the telephone line and the modem.

DAA (Data Access Arrangement): Prior to 1976, this equipment had to be leased from the telephone company as protective circuitry for the dial-up (switched) network. Now users may buy or build the necessary circuitry providing it is registered with the FCC according to Part 68 of the FCC's regulations. Also called Registered Protective Circuit.

Data Carrier Detect (DCD) Timing: On the TMS99532A and TMS99534A, turn-on time for carrier detection and turn-off time for carrier loss can be adjusted externally.

dB (Decibel): The decibel is defined by the ratio of output signal power to input signal power as follows:

$$dB = 10 * \log_{10} (\text{Output Power} / \text{Input Power})$$

If the output power is less than the input power, the logarithmic result is negative. In this case, the line is said to have a loss of that many dB.

dBm: Input and output signal power may be related to a specific level called a dBm for reference purposes. Zero dBm (log 1 = 0) equals 1 milliwatt dissipated in 600 ohms impedance. The reference frequency used in most circuits is 1000 Hz. Measurements made relative to a reference frequency are expressed in decibels relative to 1 milliwatt as follows:

$$dBm = 10 * \log_{10} (\text{Signal Power in Milliwatts} / 1 \text{ Milliwatt})$$

Thus, zero dBm means 1 milliwatt and absolute power levels may be expressed as so many dBm.

dBSPL: In acoustics, the unit commonly utilized to measure sound pressure is decibel sound pressure level or dBSPL. The zero reference for this measurement is 0.0002 dynes per square centimeter.

dBv: Microphone sensitivities are commonly related to a specific level called a dBv for reference purposes. Zero dBv (Log 1 = 0) represents one milliwatt dissipated in 1000 ohms impedance. The unit dBv is expressed in terms of the peak voltage of a signal referenced to one volt:

$$dBv = 20 * \log_{10} (\text{Peak Voltage of Signal} / 1 \text{ Volt})$$

DCE (Data Communication Equipment): Consists of the modem and any other equipment related to the transmission and reception of analog signals over the telephone lines such as the FCC approved Registered Protective Circuit.

DDD (Direct Distance Dial): Dial system for North American Telephone.

Demodulator: The modem component that converts the received analog signal into a digital signal.

Dial-Up Telephone Lines: Also referred to as the switched network lines, these lines are used in voice-grade communications. An FCC approved Registered Protective Circuit (DAA) is required for modem operation.

Direct Connection: Description of a modem connection to the switched network that uses a FCC approved Registered Protective Circuit (DAA) rather than an acoustic coupler. The modem is physically wired (connected) to the telephone network.

DTE (Data Terminal Equipment): The digital equipment that connects to a modem or to the DCE.

Echo Suppressors: Equipment used by telephone networks to squelch unwanted noise on the telephone lines. In the United States, echo suppressors are disabled if they see a signal from 2010 to 2240 Hz for at least 400 ms with no other substantial energy on the line, and they stay disabled so long as energy (at any frequency) on the line has gaps no more than 100 ms long. Elsewhere, the frequency range for disabling echo suppressors is from 2079 to 2121 Hz.

EIA (Electronic Industries Association) RS-232C: The recognized standard serial communications interface often used between a modem and the line controller on the switched network.

Envelope Delay Distortion: Variation of signal delay with frequency in the communications channel bandwidth.

Equalization: Modem circuitry that compensates for the telephone line's electrical characteristics.

FCC (Federal Communications Commission): Government agency that establishes communications standards. Part 68 of the FCC's regulations specifies the conditions for direct connections to the switched telephone network.

Fixed Loop Loss Transmit Level Control: This type of connecting arrangement permits a maximum adjustable level of no greater than -4 dBm. A resistive attentuator is put in the signal path to prevent the transmit level from exceeding -12 dBm at the Central Office (CO). However, the received signal is unnecessarily attenuated.

Frequency-Shift Keying (FSK): Frequency modulation method which varies the carrier frequency to correspond with binary logic (mark/space being equivalent to logic one/zero). The changes in frequency may occur in a continuous manner or by abrupt transitions. The TMS99532A and TMS99534A implement a continuous-phase FSK scheme of modulation.

Full Duplex: Provides for simultaneous transmission and reception by both modems.

Gaussian (White) Noise: Background noise which is produced by the normal motion of electrons in conducting material. Used in bit error rate testing.

Half Duplex: Provides for either transmission or reception but each modem may perform only one function at a time.

Handshaking: Interchange of control signals to establish a data communications path.

Impulse Noise or Surge: A type of high amplitude, short duration interference on communications lines caused by such events as lightning, electrical sparking action or by the make/break action of switching devices. A DAA is required to protect the modem from such voltage surges.

Local Loop: The local loop is defined by the telephone company as the cable that connects the signal switching equipment at the Central Office (CO) to the user's telephone or modem.

Local Loop Current: DC flow in the local loop that indicates to the telephone company that a phone is in use. In telephone company terminology, a phone (or modem) is "on-hook" when no local loop current is flowing and is "off-hook" otherwise.

Long Haul Modem: May be designed for use on the public switched telephone network or for dedicated use on a leased telephone line. The TMS99532A and TMS99534A are long haul modems designed for use on the public switched telephone network.

Mark: Binary logic one in the frequency-shift keying (FSK) modulation scheme implemented on the TMS99532A and TMS99534A.

Microbar: Unit of pressure: one dyne per square centimeter. In acoustics, microphone sensitivities are commonly referenced to the following unit: 1 volt /microbar.

Modem: Device to convert digital data into an analog signal and vice versa so that two electronic devices (such as a computer and a data terminal) may communicate over an analog communication system such as the telephone system. The word modem is a contraction for modulator/demodulator.

Modulator: The modem component that converts a digital signal input into an analog signal for transmission.

Off-Hook: Telephone terminology for the electrically connected state of a data transmission system, i.e., current is flowing in the local loop.

On-Hook: Telephone terminology for the electrically disconnected state of a data transmission system, i.e., current is not flowing in the local loop.

Permissive Transmit Level Control: Arrangement that allows the transmit level of a modem to be fixed at no greater than -9 dBm regardless of loop loss.

Programmable Transmit Level Control: Arrangement that permits the transmit level to be "programmed" in 1 dB steps from 0 to -12 dBm using a programming resister in the connecting circuitry supplied by the telephone company. The value of this resistor represents the local loop loss and is defined in Part 68 of the FCC's regulations.

Protocol: A set of conventions including handshaking and line control functions for communication processes.

Registered Protective Circuit: Part 68 of the FCC's regulations stipulates that all devices connected to the switched network have Registered Protective Circuits to prevent damage to the telephone company's equipment.

Signal-To-Noise Ratio (SNR): An expression in decibels of the relative signal and noise power levels present on a communications line. Important for modem diagnostics.

Simplex: Provides for one-way transmission and reception in the following manner: one modem is transmit-only and the other modem is receive-only.

Space: Binary logic zero in the frequency-shift keying (FSK) modulation scheme implemented on the TMS99532A and TMS99534A.

Switched Network Telephone Lines: See Dial-Up Telephone Lines.

Two-To-Four Wire Hybrid (Duplexer): Since the telephone line is a two wire system that mixes the transmitted and received analog signals, the modem requires a two-to-four wire hybrid to separate these signals. The two telephone wires are normally called "TIP" and "RING". The four wires of the hybrid refer to the transmitter output and ground plus the receiver input and ground.

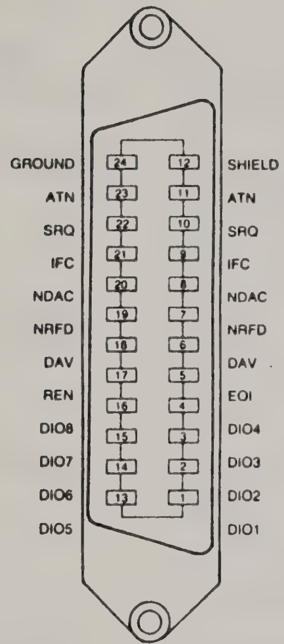
ASCII Standards

ANSI American Standard Code
for Information Interchange (ASCII)

Bits b_7 b_6 b_5 →					0 0 0	0 0 1	0 1 0	0 1 1	1 0 0	1 0 1	1 1 0	1 1 1
b_4 ↓	b_3 ↓	b_2 ↓	b_1 ↓	COLUMN → / ROW ↓	0	1	2	3	4	5	6	7
0	0	0	0	0	NUL	DLE	SP	0	@	P	`	p
0	0	0	1	1	SOH	DC1	!	1	A	Q	a	q
0	0	1	0	2	STX	DC2	"	2	B	R	b	r
0	0	1	1	3	ETX	DC3	#	3	C	S	c	s
0	1	0	0	4	EOT	DC4	$	4	D	T	d	t
0	1	0	1	5	ENQ	NAK	%	5	E	U	e	u
0	1	1	0	6	ACK	SYN	&	6	F	V	f	v
0	1	1	1	7	BEL	ETB	'	7	G	W	g	w
1	0	0	0	8	BS	CAN	(	8	H	X	h	x
1	0	0	1	9	HT	EM	)	9	I	Y	i	y
1	0	1	0	10	LF	SUB	*	:	J	Z	j	z
1	0	1	1	11	VT	ESC	+	;	K	[	k	{
1	1	0	0	12	FF	FS	,	<	L	\	l	|
1	1	0	1	13	CR	GS	-	=	M	]	m	}
1	1	1	0	14	SO	RS	.	>	N	^	n	~
1	1	1	1	15	SI	US	/	?	O	_	o	DEL

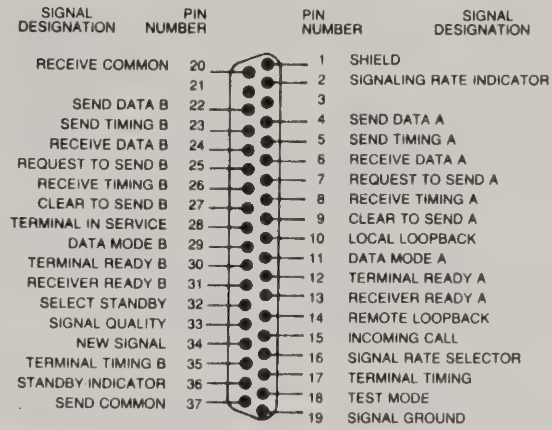
NUL = All zeros
SOH = Start of heading
STX = Start of text
ETX = End of Text
EOT = End of transmission
ENQ = Enquiry
ACK = Acknowledgement
BEL = Bell or attention signal
BS = Back space
HT = Horizontal tabulation
LF = Line feed
VT = Vertical tabulation
FF = Form feed
CR = Carriage return
SO = Shift out
SI = Shift in
DLE = Data link escape
DC 1 = Device control 1
DC 2 = Device control 2
DC 3 = Device control 3
DC 4 = Device control 4
NAK = Negative acknowledgement
SYN = Synchronous/idle
ETB = End of transmitted block
CAN = Cancel (error in data)
EM = End of medium
SUB = Start of special sequence
ESC = Escape
FS = Information file separator
GS = Information group separator
RS = Information record separator
US = Information unit separator
DEL = Delete

IEEE-488 Interface

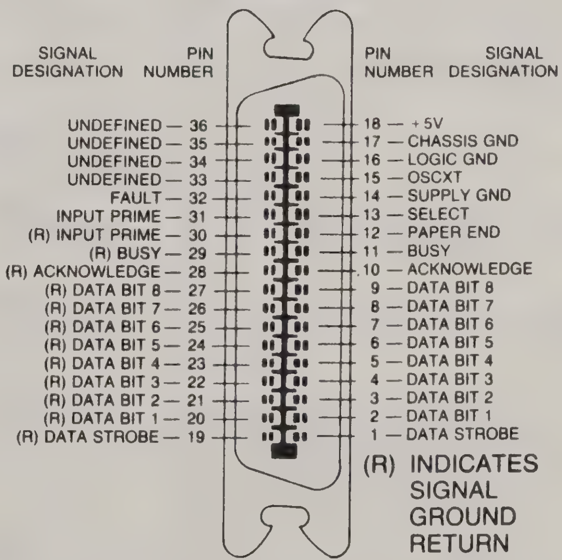


DIO1	Data I Input/Output 1
•	•
•	•
•	•
DIO8	Data Input/Output 8
DAV	Data Valid
NRFD	Not Ready for Data
NDAC	Not Data Accepted
IFC	Interface Clear
ATN	Attention
SRQ	Service Request
REN	Remote Enable
EOI	End or Identify

RS-449 Interface

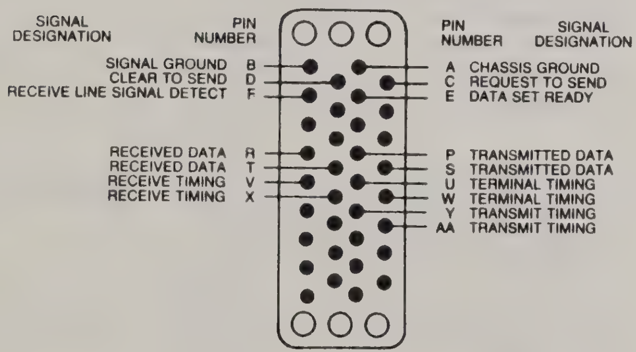


Parallel Interface (Centronics type)

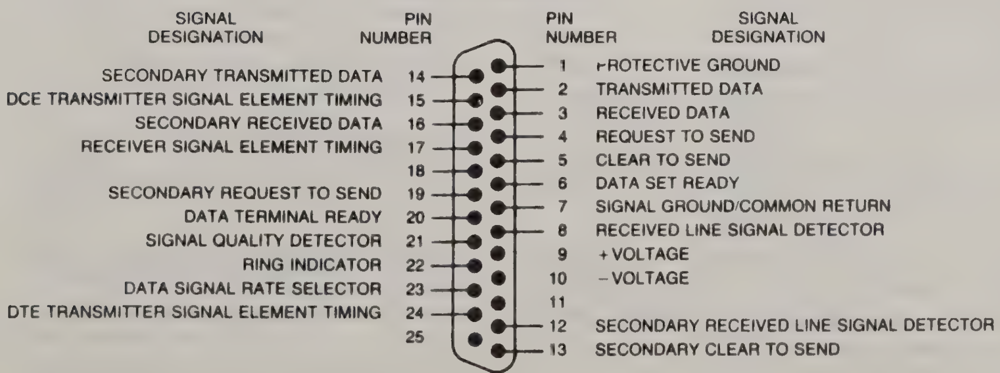


(R) INDICATES SIGNAL GROUND RETURN

V.35 Interface



RS-232 Interface



Connector Glossary

BNC Connector: Features a bayonet coupling, used where quick connect/disconnect is desired yet positive locking is needed.

C Connector: Similar in size to N connectors, however, with bayonet locking. The dielectric overlap provides good voltage handling capabilities, but bayonet coupling does not perform well electrically during vibration.

Coaxial Connector: Comprised of two concentric conductors separated by a dielectric (insulator) and is most commonly used as an extension of a transmission line to facilitate interconnects.

Contact: The conducting part of a connector that acts with another such part to complete or break a circuit. Contacts provide a separable through connection in a cable to cable, cable to module, or module to module situation.

Hermaphroditic Connector: An interconnecting device in which both mating parts are identical at their mating surfaces. Also called Sexless Connectors.

Hermetic: Airtight. Since all materials are permeable, specifications define acceptable levels of hermeticity. The maximum allowable leak rate for coaxial connectors is usually specified as less than 1×10^{-8} cc/sec. standard air equivalent with one atmosphere differential.

HN Connector: Slightly larger than N, but uses basically the same cable. It is designed to have increased voltage capabilities without the loss of its RF parameters through about 4 GHz.

Insertion Loss: The loss in load power resulting from the insertion of a connector, component or device.

Instrumentation Grade: A connector designed to give superior RF performance. This normally is a test port connector and is used for precision microwave measurement. A high degree of repeatability can be expected. It is not designed for use in harsh environments.

Interface: The physical connection between two systems or devices or the matching of adjacent components, circuits or equipment.

MHV Connector: High voltage version of the BNC. Ground connection is broken before power connection. Inactivated under MIL-C-39012 and replaced by SHV.

Microstrip: Two parallel conductive planes separated by a dielectric. The narrow strip is the signal conductor and the wider strip is the signal ground.

Military Grade: A connector designed to give adequate RF performance and meet mechanical and environmental requirements usually seen in system applications. It is normally a high useage item.

N Connector: The first matched RF connector exhibiting good RF performance but limited voltage handling capabilities. It has threaded coupling for mating.

SC Connector: Often referred to as the Screwed C. Popular in areas which experience high vibration.

SHV Connector: Designed to replace the MHV for high energy physics applications.

SMA Connector: High performance subminiature connector. Widely used in high performance military systems and state-of-the-art test equipment, as well as where miniaturization is desired.

SMB Connector: Snap-on version of the SMC, more limited in its performance.

SMC Connector: Threaded subminiature connector. Does not have the high performance of the SMA.

SSMA Connector: Smaller than SMA for reduced packaging requirements, allows for higher frequency performance.

Stripline: Similar to microstrip except with three parallel conductors separated by dielectric. The narrow center strip is the signal conductor and the wider outer stips are the signal ground planes.

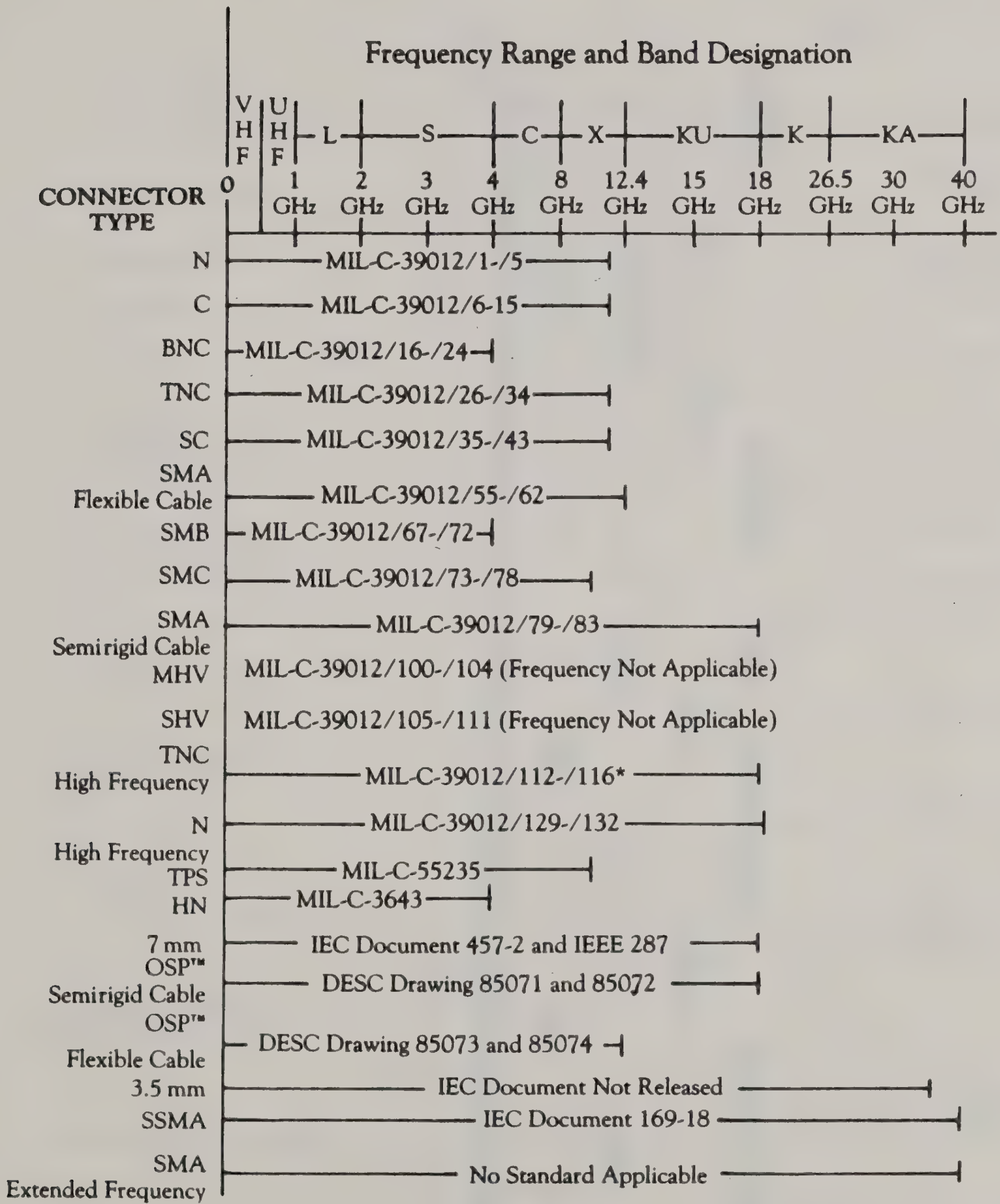
TNC Connector: Threaded version of the BNC featuring higher frequency capabilities because of their more stable mating. They are popular where the larger SC and N connectors are too big but a threaded coupling is needed.

TPS Connector: Miniature bayonet connector, smaller than BNC, with improved performance to 10 GHz.

Transmission Line: Used to guide the propagation of electromagnetic waves and confine it to prevent the loss of energy.

Voltage Standing Wave Ratio: (VSWR). The ratio of the incident wave to the reflected wave in a transmission line. This represents a figure of merit for the impedance mismatch within the line and will vary with frequency.

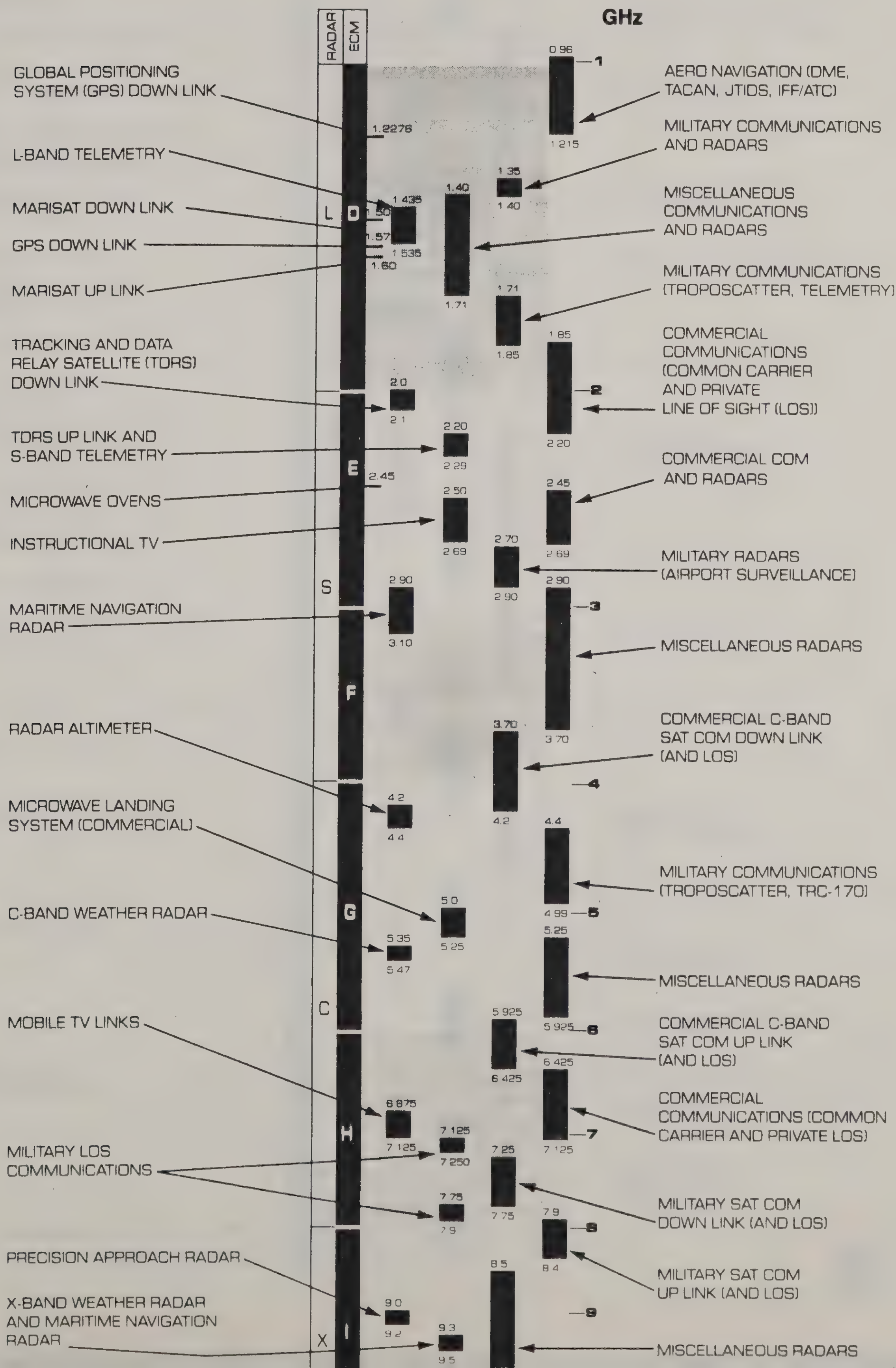
Coaxial Connector Performance



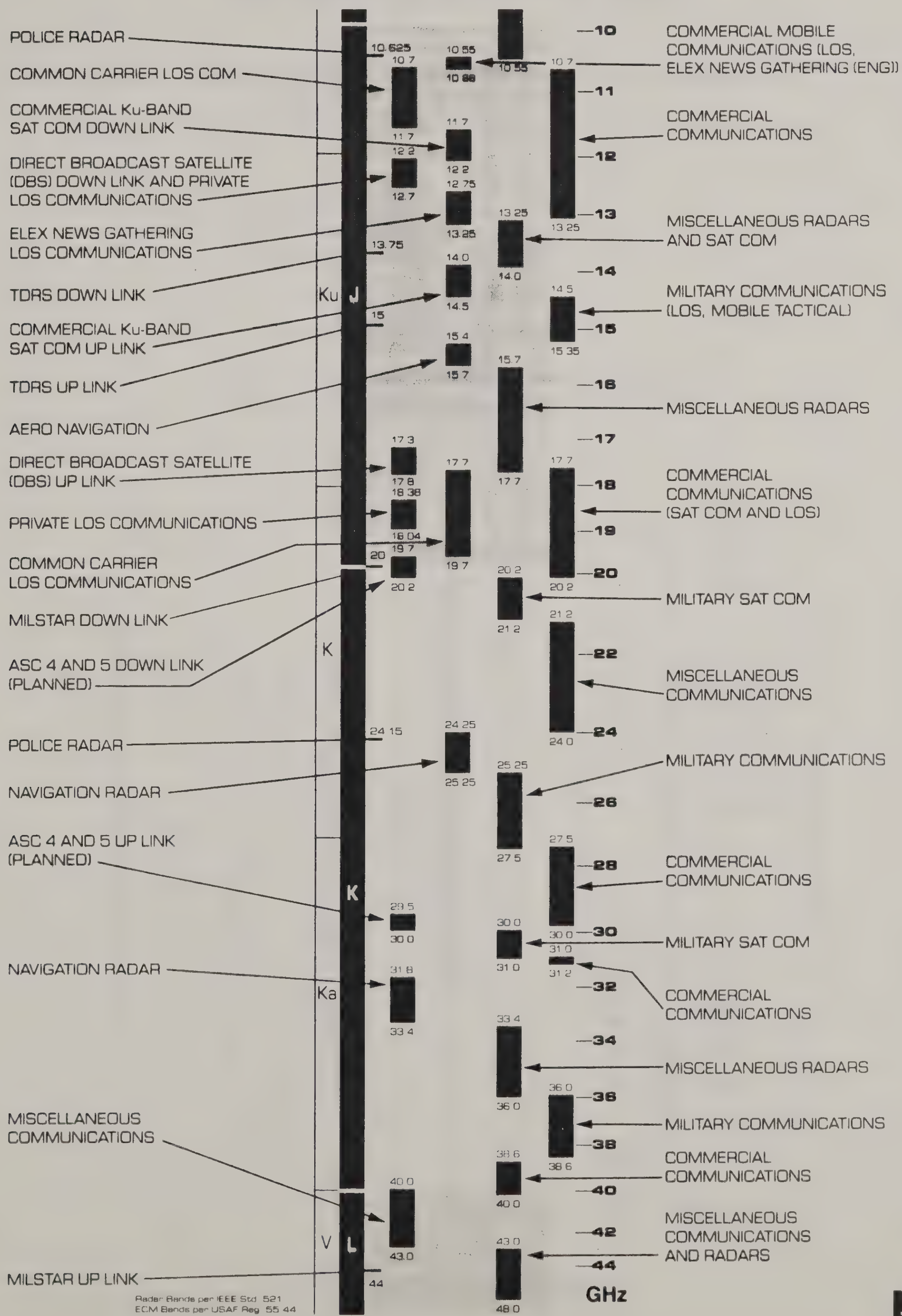
*Being revised 18 GHz

OSP is a trademark of M/A COM Omni Spectra, Inc.

United States Microwave Applications by Frequency



United States Microwave Applications by Frequency



Computing Antenna Gain

Antenna gain, G_O, in dB can be computed with following equation:

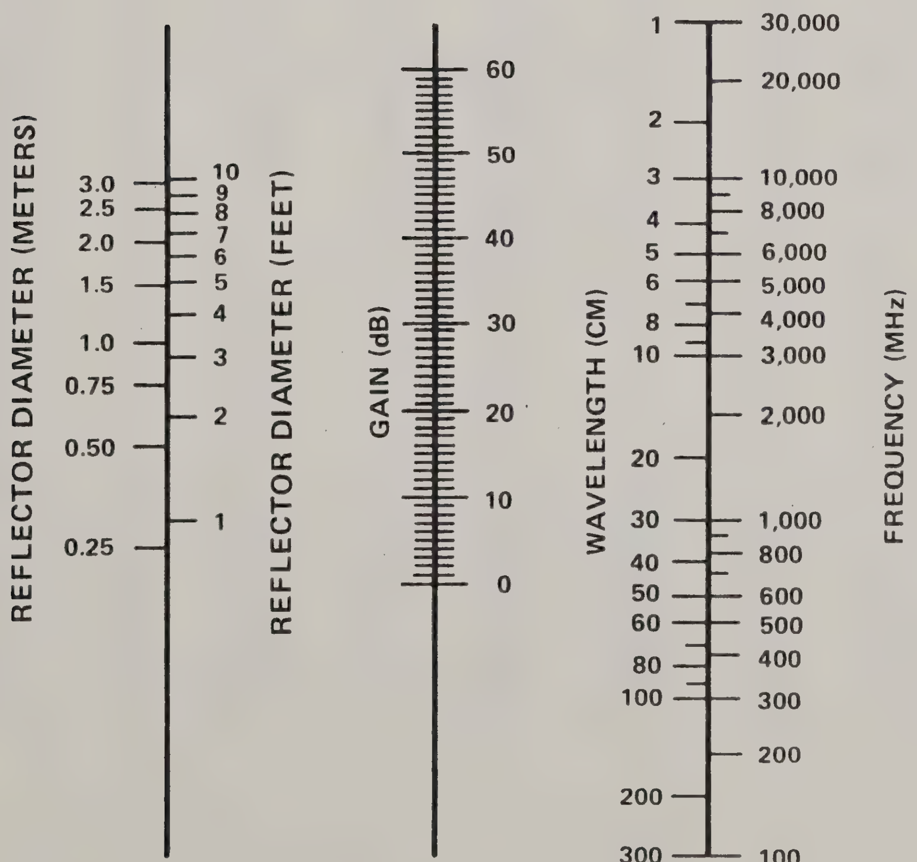
$$G_O = 20 \log \frac{D}{\lambda} + 10 \log f + 9.938$$

where:

- D = Diameter of antenna
- f = Illumination factor
- λ = Wavelength (same unit as diameter)

(An illumination factor of 0.6 is assumed)

Gain in dB can also be estimated using the nomograph below which assumes an illumination factor of 0.5.



ANTENNA GAIN NOMOGRAPH

VSWR vs. Return Loss (R)

VSWR	R dB	VSWR	R dB	VSWR	R dB	VSWR	R dB	VSWR	R dB
1.001	66.025	1.060	30.714	1.138	23.803	1.480	14.264	5.400	3.255
1.002	60.009	1.061	30.575	1.140	23.686	1.490	14.120	5.600	3.136
1.003	56.491	1.062	30.438	1.142	23.571	1.500	13.979	5.800	3.025
1.004	53.997	1.063	30.303	1.144	23.457	1.520	13.708	6.000	2.923
1.005	52.063	1.064	30.171	1.146	23.346	1.540	13.449	6.200	2.827
1.006	50.484	1.065	30.040	1.148	23.235	1.560	13.201	6.400	2.737
1.007	49.149	1.066	29.912	1.150	23.127	1.580	12.964	6.600	2.653
1.008	47.993	1.067	29.785	1.152	23.020	1.600	12.736	6.800	2.573
1.009	46.975	1.068	29.661	1.154	22.914	1.620	12.518	7.000	2.499
1.010	46.064	1.069	29.538	1.156	22.810	1.640	12.308	7.200	2.428
1.011	45.240	1.070	29.417	1.158	22.708	1.660	12.107	7.400	2.362
1.012	44.489	1.071	29.298	1.160	22.607	1.680	11.913	7.600	2.299
1.013	43.798	1.072	29.181	1.162	22.507	1.700	11.725	7.800	2.239
1.014	43.159	1.073	29.066	1.164	22.408	1.720	11.545	8.000	2.183
1.015	42.564	1.074	28.952	1.166	22.311	1.740	11.370	8.200	2.129
1.016	42.007	1.075	28.839	1.168	22.215	1.760	11.202	8.400	2.078
1.017	41.485	1.076	28.728	1.170	22.120	1.780	11.039	8.600	2.029
1.018	40.993	1.077	28.619	1.172	22.027	1.800	10.881	8.800	1.983
1.019	40.528	1.078	28.511	1.174	21.934	1.820	10.729	9.000	1.938
1.020	40.086	1.079	28.405	1.176	21.843	1.840	10.581	9.200	1.896
1.021	39.667	1.080	28.299	1.178	21.753	1.860	10.437	9.400	1.855
1.022	39.867	1.081	28.196	1.180	21.664	1.880	10.298	9.600	1.816
1.023	38.885	1.082	28.093	1.182	21.576	1.900	10.163	9.800	1.779
1.024	38.520	1.083	27.992	1.184	21.489	1.920	10.032	10.000	1.743
1.025	38.170	1.084	27.892	1.186	21.403	1.940	9.904	11.000	1.584
1.026	37.833	1.085	27.794	1.188	21.318	1.960	9.780	12.000	1.451
1.027	37.510	1.086	27.696	1.190	21.234	1.980	9.660	13.000	1.339
1.028	37.198	1.087	27.600	1.192	21.151	2.000	9.542	14.000	1.243
1.029	36.898	1.088	27.505	1.194	21.069	2.100	8.999	15.000	1.160
1.030	36.607	1.089	27.411	1.196	21.988	2.200	8.519	16.000	1.087
1.031	36.327	1.090	27.318	1.198	20.907	2.300	8.091	17.000	1.023
1.032	36.055	1.091	27.226	1.200	20.828	2.400	7.707	18.000	0.966
1.033	35.792	1.092	27.135	1.210	20.443	2.500	7.360	19.000	0.915
1.034	35.537	1.093	27.046	1.220	20.079	2.600	7.044	20.000	0.869
1.035	35.290	1.094	26.957	1.230	19.732	2.700	6.755	22.000	0.790
1.036	35.049	1.095	26.869	1.240	19.401	2.800	6.490	24.000	0.724
1.037	34.816	1.096	26.782	1.250	19.085	2.900	6.246	26.000	0.668
1.038	34.588	1.097	26.697	1.260	18.783	3.000	6.021	28.000	0.621
1.039	34.367	1.098	26.612	1.270	18.493	3.100	5.811	30.000	0.579
1.040	34.151	1.099	26.528	1.280	18.216	3.200	5.617	32.000	0.543
1.041	33.941	1.100	26.444	1.290	17.949	3.300	5.435	34.000	0.511
1.042	33.763	1.102	26.281	1.300	17.692	3.400	5.265	36.000	0.483
1.043	33.536	1.104	26.120	1.310	17.445	3.500	5.105	38.000	0.457
1.044	33.341	1.106	25.963	1.320	17.207	3.600	4.956	40.000	0.434
1.045	33.150	1.108	25.809	1.330	16.977	3.700	4.815	42.000	0.414
1.046	32.963	1.110	25.658	1.340	16.755	3.800	4.682	44.000	0.395
1.047	32.780	1.112	25.510	1.350	16.540	3.900	4.556	46.000	0.378
1.048	32.602	1.114	25.364	1.360	16.332	4.000	4.437	48.000	0.362
1.049	32.427	1.116	25.221	1.370	16.131	4.100	4.324	50.000	0.347
1.050	32.256	1.118	25.081	1.380	15.936	4.200	4.217	55.000	0.316
1.051	32.088	1.120	24.943	1.390	15.747	4.300	4.115	60.000	0.290
1.052	31.923	1.122	24.808	1.400	15.563	4.400	4.018	65.000	0.267
1.053	31.762	1.124	24.675	1.410	15.385	4.500	3.926	70.000	0.248
1.054	31.604	1.126	24.544	1.420	15.211	4.600	3.838	75.000	0.232
1.055	31.449	1.128	24.415	1.430	15.043	4.700	3.753	80.000	0.217
1.056	31.297	1.130	24.289	1.440	14.879	4.800	3.673	85.000	0.204
1.057	31.147	1.132	24.164	1.450	14.719	4.900	3.596	90.000	0.193
1.058	31.000	1.134	24.042	1.460	14.564	5.000	3.522	95.000	0.183
1.059	30.856	1.136	23.921	1.470	14.412	5.200	3.383	100.000	0.174

dBm to Watts

dBm	Milliwatt	dBm	Milliwatt	dBm	Milliwatt	dBm	Milliwatt	dBm	Milliwatt	dBm	Milliwatt	dBm	Milliwatt
-18.0	0.0158	-11.1	0.0776	-4.2	0.380	2.7	1.86	9.6	9.12	16.5	44.7	23.4	219
-17.9	0.0162	-11.0	0.0794	-4.1	0.389	2.8	1.91	9.7	9.33	16.6	45.7	23.5	224
-17.8	0.0166	-10.9	0.0813	-4.0	0.398	2.9	1.95	9.8	9.55	16.7	46.8	23.6	229
-17.7	0.0170	-10.8	0.0832	-3.9	0.407	3.0	2.00	9.9	9.77	16.8	47.9	23.7	234
-17.6	0.0174	-10.7	0.0851	-3.8	0.417	3.1	2.04	10.0	10.0	16.9	49.0	23.8	240
-17.5	0.0178	-10.6	0.0871	-3.7	0.427	3.2	2.09	10.1	10.2	17.0	50.1	23.9	245
-17.4	0.0182	-10.5	0.0891	-3.6	0.437	3.3	2.14	10.2	10.5	17.1	51.3	24.0	251
-17.3	0.0186	-10.4	0.0912	-3.5	0.447	3.4	3.19	10.3	10.7	17.2	52.5	24.1	257
-17.2	0.0191	-10.3	0.0933	-3.4	0.457	3.5	2.24	10.4	11.0	17.3	53.7	24.2	263
-17.1	0.0195	-10.2	0.0955	-3.3	0.468	3.6	2.29	10.5	11.2	17.4	55.0	24.3	269
-17.0	0.0200	-10.1	0.0977	-3.2	0.479	3.7	2.34	10.6	11.5	17.5	56.2	24.4	275
-16.9	0.0204	-10.0	0.100	-3.1	0.490	3.8	2.40	10.7	11.7	17.6	57.5	24.5	282
-16.8	0.0209	-9.9	0.102	-3.0	0.501	3.9	2.45	10.8	12.0	17.7	58.9	24.6	288
-16.7	0.0214	-9.8	0.105	-2.9	0.513	4.0	2.51	10.9	12.3	17.8	60.3	24.7	295
-16.6	0.0219	-9.7	0.107	-2.8	0.525	4.1	2.57	11.0	12.6	17.9	61.7	24.8	302
-16.5	0.0224	-9.6	0.110	-2.7	0.537	4.2	2.63	11.1	12.9	18.0	63.1	24.9	309
-16.4	0.0229	-9.5	0.112	-2.6	0.550	4.3	2.69	11.2	13.2	18.1	64.6	25.0	316
-16.3	0.0234	-9.4	0.115	-2.5	0.562	4.4	2.75	11.3	13.5	18.2	66.1	25.1	324
-16.2	0.0240	-9.3	0.117	-2.4	0.575	4.5	2.82	11.4	13.8	18.3	67.6	25.2	331
-16.1	0.0245	-9.2	0.120	-2.3	0.589	4.6	2.88	11.5	14.1	18.4	69.2	25.3	339
-16.0	0.0251	-9.1	0.123	-2.2	0.603	4.7	2.95	11.6	14.5	18.5	70.8	25.4	347
-15.9	0.0257	-9.0	0.126	-2.1	0.617	4.8	3.02	11.7	14.8	18.6	72.4	25.5	355
-15.8	0.0263	-8.9	0.129	-2.0	0.631	4.9	3.09	11.8	15.1	18.7	74.1	25.6	363
-15.7	0.0269	-8.8	0.132	-1.9	0.646	5.0	3.16	11.9	15.5	18.8	75.9	25.7	372
-15.6	0.0275	-8.7	0.135	-1.8	0.661	5.1	3.24	12.0	15.8	18.9	77.6	25.8	380
-15.5	0.0282	-8.6	0.138	-1.7	0.676	5.2	3.31	12.1	16.2	19.0	79.4	25.9	389
-15.4	0.0288	-8.5	0.141	-1.6	0.692	5.3	3.39	12.2	16.6	19.1	81.3	26.0	398
-15.3	0.0295	-8.4	0.145	-1.5	0.708	5.4	3.47	12.3	17.0	19.2	83.2	26.1	407
-15.2	0.0302	-8.3	0.148	-1.4	0.724	5.5	3.55	12.4	17.4	19.3	85.1	26.2	417
-15.1	0.0309	-8.2	0.151	-1.3	0.741	5.6	3.63	12.5	17.8	19.4	87.1	26.3	427
-15.0	0.0316	-8.1	0.155	-1.2	0.759	5.7	3.72	12.6	18.2	19.5	89.1	26.4	437
-14.9	0.0324	-8.0	0.158	-1.1	0.776	5.8	3.80	12.7	18.6	19.6	91.2	26.5	447
-14.8	0.0331	-7.9	0.162	-1.0	0.794	5.9	3.89	12.8	19.1	19.7	93.3	26.6	457
-14.7	0.0339	-7.8	0.166	-0.9	0.813	6.0	3.98	12.9	19.5	19.8	95.5	26.7	468
-14.6	0.0347	-7.7	0.170	-0.8	0.832	6.1	4.07	13.0	20.0	19.9	97.7	26.8	479
-14.5	0.0355	-7.6	0.174	-0.7	0.851	6.2	4.17	13.1	20.4	20.0	100	26.9	490
-14.4	0.0363	-7.5	0.178	-0.6	0.871	6.3	4.27	13.2	20.9	20.1	102	27.0	501
-14.3	0.0372	-7.4	0.182	-0.5	0.891	6.4	4.37	13.3	21.4	20.2	105	27.1	513
-14.2	0.0380	-7.3	0.186	-0.4	0.912	6.5	4.47	13.4	21.9	20.3	107	27.2	525
-14.1	0.0389	-7.2	0.191	-0.3	0.933	6.6	4.57	13.5	22.4	20.4	110	27.3	537
-14.0	0.0398	-7.1	0.195	-0.2	0.955	6.7	4.68	13.6	22.9	20.5	112	27.4	550
-13.9	0.0407	-7.0	0.200	-0.1	0.977	6.8	4.79	13.7	23.4	20.6	115	27.5	562
-13.8	0.0417	-6.9	0.204	0.0	1.00	6.9	4.90	13.8	24.0	20.7	117	27.6	575
-13.7	0.0427	-6.8	0.209	0.1	1.02	7.0	5.01	13.9	24.5	20.8	120	27.7	589
-13.6	0.0437	-6.7	0.214	0.2	1.05	7.1	5.13	14.0	25.1	20.9	123	27.8	603
-13.5	0.0447	-6.6	0.219	0.3	1.07	7.2	5.25	14.1	25.7	21.0	126	27.9	617
-13.4	0.0457	-6.5	0.224	0.4	1.10	7.3	5.37	14.2	26.3	21.1	129	28.0	631
-13.3	0.0468	-6.4	0.229	0.5	1.12	7.4	5.50	14.3	26.9	21.2	132	28.1	646
-13.2	0.0479	-6.3	0.234	0.6	1.15	7.5	5.62	14.4	27.5	21.3	135	28.2	661
-13.1	0.0490	-6.2	0.240	0.7	1.17	7.6	5.75	14.5	28.2	21.4	138	28.3	676
-13.0	0.0501	-6.1	0.245	0.8	1.20	7.7	5.89	14.6	28.8	21.5	141	28.4	692
-12.9	0.0513	-6.0	0.251	0.9	1.23	7.8	6.03	14.7	29.5	21.6	145	28.5	708
-12.8	0.0525	-5.9	0.257	1.0	1.26	7.9	6.17	14.8	30.2	21.7	148	28.6	724
-12.7	0.0537	-5.8	0.263	1.1	1.29	8.0	6.31	14.9	30.9	21.8	151	28.7	741
-12.6	0.0550	-5.7	0.269	1.2	1.32	8.1	6.46	15.0	31.6	21.9	155	28.8	759
-12.5	0.0562	-5.6	0.275	1.3	1.35	8.2	6.61	15.1	32.4	22.0	158	28.9	776
-12.4	0.0575	-5.5	0.282	1.4	1.38	8.3	6.76	15.2	33.1	22.1	162	29.0	794
-12.3	0.0589	-5.4	0.288	1.5	1.41	8.4	6.92	15.3	33.9	22.2	166	29.1	813
-12.2	0.0603	-5.3	0.295	1.6	1.45	8.5	7.08	15.4	34.7	22.3	170	29.2	832
-12.1	0.0617	-5.2	0.302	1.7	1.48	8.6	7.24	15.5	35.5	22.4	174	29.3	852
-12.0	0.0631	-5.1	0.309	1.8	1.51	8.7	7.41	15.6	36.3	22.5	178	29.4	871
-11.9	0.0646	-5.0	0.316	1.9	1.55	8.8	7.59	15.7	37.2	22.6	182	29.5	891
-11.8	0.0661	-4.9	0.324	2.0	1.58	8.9	7.76	15.8	38.0	22.7	186	29.6	912
-11.7	0.0676	-4.8	0.331	2.1	1.62	9.0	7.94	15.9	38.9	22.8	191	29.7	933
-11.6	0.0692	-4.7	0.339	2.2	1.66	9.1	8.13	16.0	39.8	22.9	195	29.8	955
-11.5	0.0708	-4.6	0.347	2.3	1.70	9.2	8.32	16.1	40.7	23.0	200	29.9	977
-11.4	0.0724	-4.5	0.355	2.4	1.74	9.3	8.51	16.2	41.7	23.1	204	30.0	1000
-11.3	0.0741	-4.4	0.363	2.5	1.78	9.4	8.71	16.3	42.7	23.2	209		
-11.2	0.0759	-4.3	0.372	2.6	1.82	9.5	8.91	16.4	43.7	23.3	214		

dBm to Watts

dBm	Watts	dBm	Watts	dBm	Watts	dBm	Watts	dBm	Watts	dBm	Watts
30.1	1.02	36.8	4.79	43.5	22.40	50.2	105.00	56.9	490.00	63.6	2290.00
30.2	1.05	36.9	4.90	43.6	22.90	50.3	107.00	57.0	501.00	63.7	2340.00
30.3	1.07	37.0	5.01	43.7	23.40	50.4	110.00	57.1	513.00	63.8	2400.00
30.4	1.10	37.1	5.13	43.8	24.00	50.5	112.00	57.2	525.00	63.9	2450.00
30.5	1.12	37.2	5.25	43.9	24.50	50.6	115.00	57.3	537.00	64.0	2510.00
30.6	1.15	37.3	5.37	44.0	25.10	50.7	117.00	57.4	550.00	64.1	2570.00
30.7	1.17	37.4	5.50	44.1	25.70	50.8	120.00	57.5	562.00	64.2	2630.00
30.8	1.20	37.5	5.62	44.2	26.30	50.9	123.00	57.6	575.00	64.3	2690.00
30.9	1.23	37.6	5.75	44.3	26.90	51.0	126.00	57.7	589.00	64.4	2750.00
31.0	1.26	37.7	5.89	44.4	27.50	51.1	129.00	57.8	603.00	64.5	2820.00
31.1	1.29	37.8	6.03	44.5	28.20	51.2	132.00	57.9	617.00	64.6	2880.00
31.2	1.32	37.9	6.17	44.6	28.80	51.3	135.00	58.0	631.00	64.7	2950.00
31.3	1.35	38.0	6.31	44.7	29.50	51.4	138.00	58.1	646.00	64.8	3020.00
31.4	1.38	38.1	6.46	44.8	30.20	51.5	141.00	58.2	661.00	64.9	3090.00
31.5	1.41	38.2	6.61	44.9	30.90	51.6	145.00	58.3	676.00	65.0	3160.00
31.6	1.45	38.3	6.76	45.0	31.60	51.7	148.00	58.4	692.00	65.1	3240.00
31.7	1.48	38.4	6.92	45.1	32.40	51.8	151.00	58.5	708.00	65.2	3310.00
31.8	1.51	38.5	7.08	45.2	33.10	51.9	155.00	58.6	724.00	65.3	3390.00
31.9	1.55	38.6	7.24	45.3	33.90	52.0	158.00	58.7	741.00	65.4	3470.00
32.0	1.58	38.7	7.41	45.4	34.70	52.1	162.00	58.8	759.00	65.5	3550.00
32.1	1.62	38.8	7.59	45.5	35.50	52.2	166.00	58.9	776.00	65.6	3630.00
32.2	1.66	38.9	7.76	45.6	36.30	52.3	170.00	59.0	794.00	65.7	3720.00
32.3	1.70	39.0	7.94	45.7	37.20	52.4	174.00	59.1	813.00	65.8	3800.00
32.4	1.74	39.1	8.13	45.8	38.00	52.5	178.00	59.2	832.00	65.9	3890.00
32.5	1.78	39.2	8.32	45.9	38.90	52.6	182.00	59.3	851.00	66.0	3980.00
32.6	1.82	39.3	8.51	46.0	39.80	52.7	186.00	59.4	871.00	66.1	4070.00
32.7	1.86	39.4	8.71	46.1	40.70	52.8	191.00	59.5	891.00	66.2	4170.00
32.8	1.91	39.5	8.91	46.2	41.70	52.9	195.00	59.6	912.00	66.3	4270.00
32.9	1.95	39.6	9.12	46.3	42.70	53.0	200.00	59.7	933.00	66.4	4370.00
33.0	2.00	39.7	9.33	46.4	43.70	53.1	204.00	59.8	955.00	66.5	4470.00
33.1	2.04	39.8	9.55	46.5	44.70	53.2	209.00	59.9	977.00	66.6	4570.00
33.2	2.09	39.9	9.77	46.6	45.70	53.3	214.00	60.0	1000.00	66.7	4680.00
33.3	2.14	40.0	10.00	46.7	46.80	53.4	219.00	60.1	1020.00	66.8	4790.00
33.4	2.19	40.1	10.20	46.8	47.90	53.5	224.00	60.2	1050.00	66.9	4900.00
33.5	2.24	40.2	10.50	46.9	49.00	53.6	229.00	60.3	1070.00	67.0	5010.00
33.6	2.29	40.3	10.70	47.0	51.10	53.7	234.00	60.4	1100.00	67.1	5130.00
33.7	2.34	40.4	11.00	47.1	51.30	53.8	240.00	60.5	1120.00	67.2	5250.00
33.8	2.40	40.5	11.20	47.2	52.50	53.9	245.00	60.6	1150.00	67.3	5370.00
33.9	2.45	40.6	11.50	47.3	53.70	54.0	251.00	60.7	1170.00	67.4	5500.00
34.0	2.51	40.7	11.70	47.4	55.00	54.1	257.00	60.8	1200.00	67.5	5620.00
34.1	2.57	40.8	12.00	47.5	56.20	54.2	263.00	60.9	1230.00	67.6	5750.00
34.2	2.63	40.9	12.30	47.6	57.20	54.3	269.00	61.0	1260.00	67.7	5890.00
34.3	2.69	41.0	12.60	47.7	58.90	54.4	275.00	61.1	1290.00	67.8	6030.00
34.4	2.75	41.1	12.90	47.8	60.30	54.5	282.00	61.2	1320.00	67.9	6170.00
34.5	2.82	41.2	13.20	47.9	61.70	54.6	288.00	61.3	1350.00	68.0	6310.00
34.6	2.88	41.3	13.50	48.0	63.10	54.7	295.00	61.4	1380.00	68.1	6460.00
34.7	2.95	41.4	13.80	48.1	64.60	54.8	302.00	61.5	1410.00	68.2	6610.00
34.8	3.02	41.5	14.10	48.2	66.10	54.9	309.00	61.6	1450.00	68.3	6760.00
34.9	3.09	41.6	14.50	48.3	67.60	55.0	316.00	61.7	1480.00	68.4	6920.00
35.0	3.16	41.7	14.80	48.4	69.20	55.1	324.00	61.8	1510.00	68.5	7080.00
35.1	3.24	41.8	15.10	48.5	70.80	55.2	331.00	61.9	1550.00	68.6	7240.00
35.2	3.31	41.9	15.50	48.6	72.40	55.3	339.00	62.0	1580.00	68.7	7410.00
35.3	3.39	42.0	15.80	48.7	74.10	55.4	347.00	62.1	1620.00	68.8	7590.00
35.4	3.47	42.1	16.20	48.8	75.90	55.5	355.00	62.2	1660.00	68.9	7760.00
35.5	3.55	42.2	16.60	48.9	77.60	55.6	363.00	62.3	1700.00	69.0	7940.00
35.6	3.63	42.3	17.00	49.0	79.40	55.7	372.00	62.4	1740.00	69.1	8130.00
35.7	3.72	42.4	17.40	49.1	81.30	55.8	380.00	62.5	1780.00	69.2	8320.00
35.8	3.80	42.5	17.80	49.2	83.20	55.9	389.00	62.6	1820.00	69.3	8510.00
35.9	3.89	42.6	18.20	49.3	85.10	56.0	398.00	62.7	1860.00	69.4	8710.00
36.0	3.98	42.7	18.60	49.4	87.10	56.1	407.00	62.8	1910.00	69.5	8910.00
36.1	4.07	42.8	19.10	49.5	89.10	56.2	417.00	62.9	1950.00	69.6	9120.00
36.2	4.17	42.9	19.50	49.6	91.20	56.3	427.00	63.0	2000.00	69.7	9330.00
36.3	4.27	43.0	20.00	49.7	93.30	56.4	437.00	63.1	2040.00	69.8	9550.00
36.4	4.37	43.1	20.40	49.8	95.50	56.5	447.00	63.2	2090.00	69.9	9770.00
36.5	4.47	43.2	20.90	49.9	97.70	56.6	457.00	63.3	2140.00	70.0	10000.00
36.6	4.57	43.3	21.40	50.0	100.00	56.7	468.00	63.4	2190.00		
36.7	4.68	43.4	21.90	50.1	102.00	56.8	479.00	63.5	2240.00		

Types of Thermocouples

The thermocouple combinations most commonly used bear the instrument Society of America (ISA) designations of Types S, R, J, T, K and E. The following types are base metal:

Type J Iron-Constantan
K Chromel-Alumel*
T Copper-Constantan
E Chromel*-Constantan

The most common noble metal thermocouple are:

Type S Platinum, 10% Rhodium-Platinum
R Platinum, 13% Rhodium-Platinum

In addition, curves have recently been established by NBS for a relatively new noble metal thermocouple which is now coming into increasing use:

Type B Platinum, 30% Rhodium-Platinum
6% Rhodium

Letter designations have not been established for such thermocouples as Iridium-Iridium, Rhodium; Tungsten-Tungsten, Rhenium; and other exotic materials. Assemblies using some of the more popular combinations are available on request.

The following table provides a description of the characteristics of these thermocouples and a few precautions to be observed in their use.

*Trademark of Hoskins Mfg. Co.

Type Description	Usable Temp. Range	Advantages	Restrictions
J Iron-Constantan	−310 F/1600 F	1. Comparatively inexpensive. 2. Suitable for continuous service to 1600 F in neutral or reducing atmospheres.	1. Maximum upper limit in oxidizing atmosphere is 1400 F due to iron oxidizing. 2. Protecting tubes should be used above 900 F. 3. Protecting tubes should always be used in a contaminating medium
K Chromel-Alumel	0 F/2500 F	1. Suitable for oxidizing atmospheres. 2. In higher temperature ranges provide a more mechanically and thermally rugged unit than platinum and longer life than iron-constantan.	1. Especially vulnerable to reducing atmospheres requiring substantial protection when used.
T Copper-Constantan	−310 F/700 F	1. Resists atmosphere corrosion. 2. Applicable to reducing or oxidizing below 600 F. 3. Its stability makes useful at subzero temperatures. 4. High conformity to published calibration data.	1. Copper readily oxidizes above 600 F.
E Chromel-Constantan	−300 F/1600 F	1. High thermoelectric power. 2. Both elements highly corrosion resistant lending themselves to use in oxidizing atmospheres. 3. Does not corrode at subzero temperatures.	1. Unsatisfactory stability in reducing atmosphere.
S Platinum, 10% Rhodium-Platinum	0 F/2800 F	1. Useful in oxidizing atmospheres. 2. Provides a higher useful range than Chromel-Alumel. 3. Frequently more practical than alternate non-contact pyrometers. 4. High conformity to published calibration data.	1. Easily contaminated in other than oxidizing atmospheres.
R Platinum, 13% Rhodium-Platinum	0 F/2800 F		
B Platinum, 30% Rhodium-Platinum, 6% Rhodium	1600 F/3100 F	1. Better stability than Type R and S. 2. Increased mechanical strength. 3. Used to higher temperatures than Type R and S. 4. Reference junction compensation is not required if junction temp. does not exceed 150 F.	1. Does not exist in premium grade, only standard. 2. High temperature limit requires alumina insulators and protecting tubes. 3. Easily contaminated in other than oxidizing atmospheres.

Upper temperature limits are a function of wire diameter. Since temperature tends to have deleterious effects on thermocouples, the larger amount of material in the thermocouple cross-section, the longer it can be expected to last.

Metric Symbols

Multiples and Submultiples	Prefixes	Symbols
1,000,000,000,000 = 10^{12}	tera	T
1,000,000,000 = 10^{9}	giga	G
1,000,000 = 10^{6}	mega	M
1,000 = 10^{3}	kilo	k
100 = 10^{2}	hecto	h
10 = 10	deka	dk
0.1 = 10^{-1}	deci	d
0.01 = 10^{-2}	centi	c
0.001 = 10^{-3}	milli	m
0.000001 = 10^{-6}	micro	μ*
0.000000001 = 10^{-9}	nano	n
0.000000000001 = 10^{-12}	pico	p

*1 millionth of a meter is called a *micron*, and is abbreviated simply μ.

Constants used in Electronics

Usual Symbol	Denomination	Value and Units
$F' = Ne/c$	Faraday's constant (physical scale)	9652.19 ± 0.11 emu (g mole)$^{-1}$
N	Avogadro's constant (physical scale)	$(6.02486 \pm 0.00016) \times 10^{23}$ (g mole)$^{-1}$
h	Planck's constant	$(6.62517 \pm 0.00023) \times 10^{-27}$ erg second
m	Electron rest mass	$(9.1083 \pm 0.0003) \times 10^{-28}$ g
e	Electronic charge	$(4.80286 \pm 0.00009) \times 10^{-10}$ esu
$e' = e/c$		$(1.60206 \pm 0.00003) \times 10^{-20}$ emu
e/m	Charge-to-mass ratio of electron	$(5.27305 \pm 0.00007) \times 10^{17}$ esu g^{-1}
$e'/m = e/(mc)$		$(1.75890 \pm 0.00002) \times 10^{7}$ emu g^{-1}
c	Velocity of light in vacuum†	$299\ 793.0 \pm 0.3$ km second^{-1}
$h/(mc)$	Compton wavelength of electron	$(24.2626 \pm 0.0002) \times 10^{-11}$ cm
$a_0 = h^2/(4\pi^2 me^2)$	First Bohr electron-orbit radius	$(5.29172 \pm 0.00002) \times 10^{-9}$ cm
$\sigma = \dfrac{\pi^2 k^4 8\pi^3}{60 c^2 h^3}$	Stefan-Boltzmann constant	$(0.56687 \pm 0.00010) \times 10^{-4}$ erg cm^{-2} deg^{-4} second^{-1}
$\lambda_{max}T$	Wien displacement-law constant	(0.289782 ± 0.000013) cm deg
$\mu_0 = he/(4\pi mc)$	Bohr magneton	$(0.92731 \pm 0.00002) \times 10^{-20}$ erg gauss^{-1}
Nm	Atomic mass of the electron (physical scale)	$(5.48763 \pm 0.00006) \times 10^{-4}$
M_p/Nm	Ratio, proton mass to electron mass	1836.12 ± 0.02
$E_0 = e \cdot 10^8/c$	Energy associated with 1 eV	$(1.60206 \pm 0.00003) \times 10^{-12}$ erg
$(mc^2/E_0) \times 10^{-6}$	Energy equivalent of electron mass	(0.510976 ± 0.000007) MeV
$k = R_0/N$	Boltzmann's constant	$(1.38044 \pm 0.00007) \times 10^{-16}$ erg deg^{-1}
R_∞	Rydberg wave number for infinite mass	$(109\ 737.309 \pm 0.012)$ cm^{-1}
H	Hydrogen atomic mass (physical scale)	1.008142 ± 0.000003
R_0	Gas constant per mole (physical scale)	$(8.31696 \pm 0.00034) \times 10^{7}$ erg mole^{-1} deg^{-1}
V_0	Standard volume of perfect gas (physical scale)	$(22\ 420.7 \pm 0.6)$ cm^3 atm mole^{-1}

CONVERSIONS

To convert	Into	Multiply by	Conversely multiply by
Ampere-hours	Coulombs	3,600	2.778×10^{-4}
Amperes per sq. cm	Amperes per sq. inch	6.452	.155
Ampere turns	Gilberts	1.257	.7958
Ampere turns per cm	Ampere turns per inch	2.54	.3937
Btu (British thermal unit)	Foot-pounds	778.3	1.285×10^{-3}
Btu	Joules	1,054.8	9.48×10^{-4}
Btu	Kilogram-calories	.252	3.969
Btu	Horsepower-hours	3.929×10^{-4}	2,545
Centigrade	Fahrenheit	$(C° \times 9/5) + 32$	$(F° - 32) \times 5/9$
Circular mils	Square centimeters	5.067×10^{-6}	1.973×10^{5}
Circular mils	Square mils	.7854	1.273
Cubic inches	Cubic centimeters	16.39	6.102×10^{-2}
Cubic inches	Cubic feet	5.785×10^{-4}	1,728
Cubic inches	Cubic meters	1.639×10^{-5}	6.102×10^{4}
Cubic meters	Cubic feet	35.31	2.832×10^{-2}
Cubic meters	Cubic yards	1.308	.7646
Degrees (angle)	Radians	1.745×10^{-2}	57.3
Dynes	Pounds	2.248×10^{-6}	4.448×10^{5}
Ergs	Foot-pounds	7.367×10^{-8}	1.356×10^{7}
Feet	Centimeters	30.48	3.281×10^{-2}
Foot-pounds	Horsepower-hours	5.05×10^{-7}	1.98×10^{6}
Foot-pounds	Kilogram-meters	.1383	7.233
Foot-pounds	Kilowatt-hours	3.766×10^{-7}	2.655×10^{6}
Guass	Lines per sq. inch	6.452	.155
Grams	Dynes	980.7	1.02×10^{-3}
Grams	Ounces (avoirdupois)	3.527×10^{-2}	28.35
Grams per cm	Pounds per inch	5.6×10^{-3}	178.6
Grams per cubic cm	Pounds per cu. inch	3.613×10^{-2}	27.68
Grams per sq. cm	Pounds per sq. foot	2.0481	.4883
Horsepower (550 ft.-lb. per sec.)	Foot-lb. per minute	3.3×10^{4}	3.03×10^{-5}
Horsepower (550 ft.-lb. per sec.)	Btu per minute	42.41	2.357×10^{-2}
Horsepower (550 ft.-lb. per sec.)	Kg-calories per minute	10.69	9.355×10^{-2}
Horsepower (Metric) (542 ft.-lb. per sec.)	Horsepower (550 ft.-lb. per sec.)	.9863	1.014
Inches	Centimeters	2.54	.3937
Inches	Mils	1,000	.001
Joules	Foot-pounds	.7376	1.356
Joules	Ergs	10^{7}	10^{-7}
Kilogram-calories	Kilojoules	4.186	.2389
Kilograms	Pounds (avoirdupois)	2.205	.4536
Kg. per sq. meter	Pounds per sq. foot	.2048	4.882
Kilometers	Feet	3,281	3.048×10^{-4}
Kilowatt-hours	Btu	3,413	2.93×10^{-4}
Kilowatt-hours	Foot-pounds	2.655×10^{6}	3.766×10^{-7}
Kilowatt-hours	Joules	3.6×10^{6}	2.778×10^{-7}
Kilowatt-hours	Kilogram-calories	860	1.163×10^{-3}
Kilowatt-hours	Kilogram-meters	3.671×10^{5}	2.724×10^{-6}
Liters	Cubic meters	.001	1,000
Liters	Cubic inches	61.02	1.639×10^{-2}
Liters	Gallons (liq. US)	.2642	3.785
Liters	Pints (liq. US)	2.113	.4732
Meters	Yards	1.094	.9144
Meters per min	Feet per min	3.281	.3048
Meters per min	Kilometers per hr	.06	16.67
Miles (nautical)	Kilometers	1.853	.5396
Miles (statute)	Kilometers	1.609	.6214
Miles per hr	Kilometers per min	2.682×10^{-2}	37.28
Miles per hr	Feet per min	88	1.136×10^{-1}
Miles per hr	Kilometers per hr	1.609	.6214
Poundals	Dynes	1.383×10^{4}	7.233×10^{-1}
Poundals	Pounds (avoirdupois)	3.108×10^{-2}	32.17
Sq inches	Circular mils	1.273×10^{6}	7.854×10^{-1}
Sq inches	Sq centimeters	6.452	.155
Sq feet	Sq meters	9.29×10^{-2}	10.76
Sq miles	Sq yards	3.098×10^{6}	3.228×10^{-1}
Sq miles	Sq kilometers	2.59	.3861
Sq millimeters	Circular mils	1,973	5.067×10^{-1}
Tons, short (avoir 2,000 lb.)	Tonnes (1,000 Kg.)	.9072	1.102
Tons, long (avoir 2,240 lb.)	Tonnes (1,000 Kg.)	1.016	.9842
Tons, long (avoir 2,240 lb.)	Tonnes short (avoir 2,000 lb.)	1.120	.8929
Watts	Btu per min	5.689×10^{-2}	17.58
Watts	Ergs per sec	10^{7}	10^{-7}
Watts	Ft-lb per minute	44.26	2.26×10^{-2}
Watts	Horsepower (550 ft-lb per sec.)	1.341×10^{-3}	745.7
Watts	Horsepower (metric) (542.5 ft-lb per sec.)	1.36×10^{-3}	735.5
Watts	Kg-calories per min	1.433×10^{-2}	69.77

APPENDIX B – POSITIVE POWERS OF TWO

n	2^n				n	2^n						
1	2				51	22517	99813	68524	8			
2	4				52	45035	99627	37049	6			
3	8				53	90071	99254	74099	2			
4	16				54	18014	39850	94819	84			
5	32				55	36028	79701	89639	68			
6	64				56	72057	59403	79279	36			
7	128				57	14411	51880	75855	872			
8	256				58	28823	03761	51711	744			
9	512				59	57646	07523	03423	488			
10	1024				60	11529	21504	60684	6976			
11	2048				61	23058	43009	21369	3952			
12	4096				62	46116	86018	42738	7904			
13	8192				63	92233	72036	85477	5808			
14	16384				64	18446	74407	37095	51616			
15	32768				65	36893	48814	74191	03232			
16	65536				66	73786	97629	48382	06464			
17	13107	2			67	14757	39525	89676	41292	8		
18	26214	4			68	29514	79051	79352	82585	6		
19	52428	8			69	59029	58103	58705	65171	2		
20	10485	76			70	11805	91620	71741	13034	24		
21	20971	52			71	23611	83241	43482	26068	48		
22	41943	04			72	47223	66482	86964	52136	96		
23	83886	08			73	94447	32965	73929	04273	92		
24	16777	216			74	18889	46593	14785	80854	784		
25	33554	432			75	37778	93186	29571	61709	568		
26	67108	864			76	75557	86372	59143	23419	136		
27	13421	7728			77	15111	57274	51828	64683	8272		
28	26843	5456			78	30223	14549	03657	29367	6544		
29	53687	0912			79	60446	29098	07314	58735	3088		
30	10737	41824			80	12089	25819	61462	91747	06176		
31	21474	83648			81	24178	51639	22925	83494	12352		
32	42949	67296			82	48357	03278	45851	66988	24704		
33	85899	34592			83	96714	06556	91703	33976	49408		
34	17179	86918	4		84	19342	81311	38340	66795	29881	6	
35	34359	73836	8		85	38685	62622	76681	33590	59763	2	
36	68719	47673	6		86	77371	25245	53362	67181	19526	4	
37	13743	89534	72		87	15474	25049	10672	53436	23905	28	
38	27487	79069	44		88	30948	50098	21345	06872	47810	56	
39	54975	58138	88		89	61897	00196	42690	13744	95621	12	
40	10995	11627	776		90	12379	40039	28538	02748	99124	224	
41	21990	23255	552		91	24758	80078	57076	05497	98248	448	
42	43980	46511	104		92	49517	60157	14152	10995	96496	896	
43	87960	93022	208		93	99035	20314	28304	21991	92993	792	
44	17592	18604	4416		94	19807	04062	85660	84398	38598	7584	
45	35184	37208	8832		95	39614	08125	71321	68796	77197	5168	
46	70368	74417	7664		96	79228	16251	42643	37593	54395	0336	
47	14073	74883	55328		97	15845	63250	28528	67518	70879	00672	
48	28147	49767	10656		98	31691	26500	57057	35037	41758	01344	
49	56294	99534	21312		99	63382	53001	14114	70074	83516	02688	
50	11258	99906	84262	4	100	12676	50600	22822	94014	96703	20537	6
					101	25353	01200	45645	88029	93406	41075	2

APPENDIX C – NEGATIVE POWERS OF TWO

n	2^{-n}									
0	1.0									
1	0.5									
2	0.25									
3	0.125									
4	0.0625									
5	0.03125									
6	0.01562	5								
7	0.00781	25								
8	0.00390	625								
9	0.00195	3125								
10	0.00097	65625								
11	0.00048	82812	5							
12	0.00024	41406	25							
13	0.00012	20703	125							
14	0.00006	10351	5625							
15	0.00003	05175	78125							
16	0.00001	52587	89062	5						
17	0.00000	76293	94531	25						
18	0.00000	38146	97265	625						
19	0.00000	19073	48632	8125						
20	0.00000	09536	74316	40625						
21	0.00000	04768	37158	20312	5					
22	0.00000	02384	18579	10156	25					
23	0.00000	01192	09289	55078	125					
24	0.00000	00596	04644	77539	0625					
25	0.00000	00298	02322	38769	53125					
26	0.00000	00149	01161	19384	76562	5				
27	0.00000	00074	50580	59692	38281	25				
28	0.00000	00037	25290	29846	19140	625				
29	0.00000	00018	62645	14923	09570	3125				
30	0.00000	00009	31322	57461	54785	15625				
31	0.00000	00004	65661	28730	77392	57812	5			
32	0.00000	00002	32830	64365	38696	28906	25			
33	0.00000	00001	16415	32182	69348	14453	125			
34	0.00000	00000	58207	66091	34674	07226	5625			
35	0.00000	00000	29103	83045	67337	03613	28125			
36	0.00000	00000	14551	91522	83668	51806	64062	5		
37	0.00000	00000	07275	95761	41834	25903	32031	25		
38	0.00000	00000	03637	97880	70917	12951	66015	625		
39	0.00000	00000	01818	98940	35458	56475	83007	8125		
40	0.00000	00000	00909	49470	17729	28237	91503	90625		
41	0.00000	00000	00454	74735	08864	64118	95751	95312	5	
42	0.00000	00000	00227	37367	54432	32059	47875	97656	25	
43	0.00000	00000	00113	68683	77216	16029	73937	98828	125	
44	0.00000	00000	00056	84341	88608	08014	86968	99414	0625	
45	0.00000	00000	00028	43170	94304	04007	43484	49707	03125	
46	0.00000	00000	00014	21085	47152	02003	71742	24853	51562	5
47	0.00000	00000	00007	10542	73576	01001	85871	12426	75781	25
48	0.00000	00000	00003	55271	36788	00500	92935	56213	37890	625
49	0.00000	00000	00001	77635	68394	00250	46467	78106	68945	3125
50	0.00000	00000	00000	88817	84197	00125	23233	89053	34472	65625

APPENDIX D — THE HEXADECIMAL NUMBER SYSTEM

We have been taught from childhood to recognize and manipulate a number system called decimal or base-10, which uses ten symbols to represent values or numbers. These symbols are 0, 1, 2, 3, 4, 5, 6, 7, 8, and 9. Combinations of these form other numbers, and each number or digit position is assigned a value equal to its position in the number sequence. For example, the number 12,045:

POSITION NO.	4 3 2 1 0		
	1 2 0 4 5		
		$= 5 \times 10^0 =$	5
		$= 4 \times 10^1 =$	40
		$= 0 \times 10^2 =$	000
		$= 2 \times 10^3 =$	2,000
		$= 1 \times 10^4 =$	10,000
			$12{,}045_{10}$

10 is the base-value of the number system, and 0, 1, 2, 3, 4 are the positions of weighted values.

Most computers use a base-2 numbering system in which zeros and ones are the only symbols used to represent any number. The least-significant bit would have a value of 2^0, the next bit would be 2^1, then 2^2, etc. Let's use a group of five bits and assign bit 0 as the least significant bit.

BIT NO.						
0		1		1×2^0		1
1		0		0×2^1		0
2	=	1	=	1×2^2	=	4
3		0		0×2^3		0
4		1		1×2^4		16
						21_{10}

21 is the sum of the values of the bit positions.

It can also be seen that by using larger groups of bits, larger numbers may be represented. An eight-bit computer, which can handle eight bit positions in parallel, can represent numbers from 0 to 255_{10}.

All Bits Equal 0

BIT NO.						
0		0		0×2^0		0
1		0		0×2^1		0
2		0		0×2^2		0
3	=	0	=	0×2^3	=	0
4		0		0×2^4		0
5		0		0×2^5		0
6		0		0×2^6		0
7		0		0×2^7		0
						0_{10}

All Bits Equal 1

BIT NO.						
0		1		1×2^0		1
1		1		1×2^1		2
2		1		1×2^2		4
3	=	1		1×2^3	=	8
4		1		1×2^4		16
5		1		1×2^5		32
6		1		1×2^6		64
7		1		1×2^7		128
						255_{10}

A computer that has 16 bit positions may represent numbers with values from zero to 65,535.

Another consideration in computers is the representation of both positive and negative values. In the "sign magnitude" system, this may be accomplished by assigning one of the bits in a group as a plus/minus indicator. The normal method is to assign the most-significant bit position to this task. If it is a logic zero, then the value is positive; if it is a logic one, then the value is minus. Assuming a group of eight bits maximum, and using the eighth position as the sign, we may represent the following numbers:

BIT NO.						
0		1		1×2^0		1
1		1		1×2^1		2
2		1		1×2^2		4
3	=	1	=	1×2^3	=	8
4		1		1×2^4		16
5		1		1×2^5		32
6		1		1×2^6		64
sign bit 7		0	=	+		$+127_{10}$

If bit 7 is equal to a 1, then the above number would be negative: −127. Note that by using the most-significant bit for the sign, the maximum number that may be represented is only ±127. In a 16-bit computer this number would be ±32,767.

Because it is difficult for us to convert visually many ones and zeros to their represented value, other methods of representing numbers have been implemented.

BCD OR BINARY CODED DECIMAL:

BCD uses groups of four binary bits or positions, and only uses those combinations that add up to 0, 1, 2, 3, 4, 5, 6, 7, 8, or 9. For example:

BIT	3	2	1	0		
	0	0	0	0	=	0
	0	0	0	1	=	1
	0	0	1	0	=	2
	0	0	1	1	=	3
	0	1	0	0	=	4
	0	1	0	1	=	5
	0	1	1	0	=	6
	0	1	1	1	=	7
	1	0	0	0	=	8
	1	0	0	1	=	9

The other binary combinations possible in the four bit positions are not allowed in the BCD method:

$$\left.\begin{array}{cccc} 1 & 0 & 1 & 0 \\ 1 & 0 & 1 & 1 \\ 1 & 1 & 0 & 0 \\ 1 & 1 & 0 & 1 \\ 1 & 1 & 1 & 0 \\ 1 & 1 & 1 & 1 \end{array}\right\} \text{Not Valid}$$

In an 8-bit computer, the decimal numbers 00 through 99 may be represented:

BIT POSITION 7 6 5 4

$\boxed{0\ 0\ 0\ 0}$

0

$\boxed{1\ 0\ 0\ 1}$

1×2^0 1
0×2^1 0
0×2^2 = 0
1×2^3 8
9

BIT POSITION 3 2 1 0

$\boxed{0\ 0\ 0\ 0}$

0

$\boxed{1\ 0\ 0\ 1}$

1×2^0 1
0×2^1 0
0×2^2 = 0
1×2^3 8
9

Note that the binary weighting system repeats for each four-bit group.

This is then compensated for by applying the decimal (base-10) rules to the converted numbers:

$\boxed{9\ |\ 9}$

9×10^0 = 9
9×10^1 = 90
99

(By having to weigh only up to four binary bits, you quickly become efficient at converting binary numbers to decimal form and decimal numbers to binary form.)

The maximum numbers that can be represented in an 8-bit machine is then only 99_{10} in decimal versus 255_{10} in binary.

As you can see, the efficiency of a computer is restricted because of the illegal combination in each four-bit group. Another representation of binary numbers allows for *all* combinations of the four-bit groups. This system is called hexadecimal representation.

HEXADECIMAL (HEX) NOTATION

Hex uses a numbering system of base 16, and allows for all combinations of the four-bit binary groups, as follows:

BIT POSITION: 3 2 1 0	BINARY	HEX SYMBOL
0 0 0 0	0	0
0 0 0 1	1	1
0 0 1 0	2	2
0 0 1 1	3	3
0 1 0 0	4	4
0 1 0 1	5	5
0 1 1 0	6	6
0 1 1 1	7	7
1 0 0 0	8	8
1 0 0 1	9	9
1 0 1 0	10	A
1 0 1 1	11	B
1 1 0 0	12	C
1 1 0 1	13,	D
1 1 1 0	14	E
1 1 1 1	15	F

The notations A through F are used to allow for a single-character representation of the four-bit group without duplication.

With hex we can now represent all 16 combinations of binary weights possible in a group of four bit positions. An eight bit computer can then represent the numbers 00 through FF, which is equivalent to binary 0 through 255:

BIT POSITION 7 6 5 4

$\boxed{0\ 0\ 0\ 0}$

$\boxed{1\ 1\ 1\ 1}$

1×2^0 1
1×2^1 = 2
1×2^2 4
1×2^3 8
15 = F

BIT POSITION 3 2 1 0

$\boxed{0\ 0\ 0\ 0}$

$\boxed{1\ 1\ 1\ 1}$

1×2^0 1
1×2^1 = 2
1×2^2 4
1×2^3 8
15 = F

Applying the same rules as for decimal, but using the base 16 instead of base 10:

$\boxed{F\ |\ F}$

15×16^0 = 15
15×16^1 = 240
255

Thus, binary numbers, no matter what the number of position, can easily be converted simply by dividing them up into groups of four bits. For example, in a 16-bit computer:

Hex	F	E	9	A
	∧	∧	∧	∧
Binary	1111	1110	1001	1010
	∨	∨	∨	∨
Hex	F	E	9	A

Further, the use of hex symbols as an equivalent for four binary bits requires fewer printed symbols, and most computer documentation today uses the hexadecimal code representation.

POSITIVE AND NEGATIVE NUMBERS:

In hex or in binary, the method of representing positive and negative numbers is the same. The most-significant bit of the most-significant group is set to a zero for a positive number or a one for a negative number.

If there are four groups of 4-bits each, as in a 16-bit computer, we could have:

Hex	7	F	F	F
	∧	∧	∧	∧
Binary	0111	1111	1111	1111

sign bit

This number is equivalent to +32,767.

By making the most-significant-bit a logic 1, then the number becomes:

```
 F      F      F      F
 ∧      ∧      ∧      ∧
1111   1111   1111   1111
↑
└── sign bit
```

This number is equivalent to −32,767.

The method used to represent a negative hexadecimal number depends on the type of numbering system chosen for binary arithmetic processing. Most digital computers use either the "sign magnitude" system or the twos-complement system. In the sign magnitude system, a negative value is formed by setting a sign bit—the most-significant bit of the most-significant group of bits—to one, and the remaining bits to the desired absolute value. Thus, −32,767 is represented as 1111 1111 1111 1111.

Conversely, if the most-significant-bit is a zero the number is positive; +32,767 is represented as 0111 1111 1111 1111.

In the twos-complement system—the system used in PACE—positive numbers are represented exactly as in the sign magnitude system (sign bit is a logic zero); but negative numbers are represented by the twos-complement of the absolute value of the number. Thus, −32,767 becomes, in the twos-complement system, 1000 0000 0000 0001. Appendix E shows how this conversion is accomplished.

APPENDIX E — NEGATIVE HEXADECIMAL NUMBERS

The PACE microprocessor maintains negative numbers in twos-complement form. To convert a number in hexadecimal notation to its twos-complement equivalent, subtract the number from hexadecimal 2^n, where "n" is the number of binary bits in the computer word. For a 16-bit word, "n" is 16, and 2^n is 1 0000 0000 0000 0000 (binary) or 1 0000 (hex).

Thus, the negative of 1245_{16} is:

$$\begin{array}{r} 10000 \\ \underline{-1245} \\ EDBB \end{array}$$

A hexadecimal number will be negative in the PACE CPU if the left-most digit is 8, 9, A, B, C, D, E, or F (because all of these groupings start with a one). Thus, the twos-complement of hex FACE is:

$$\begin{array}{r} 10000 \\ \underline{-FACE} \\ +0532 \end{array}$$

Perhaps an easier way to find the twos-complement of a hexadecimal number is first to take the ones-complement of the number; the ones-complement plus one is the twos-complement. The ones-complement of a number is its inverted form; simply exchange its ones for zeros, and its zeros for ones. Thus,

hexadecimal		binary equivalent		ones-complement
FACE	→	1111 1010 1100 1110	→	0000 0101 0011 0001

$$\begin{array}{r} \text{ones-complement } +1 \\ 0000\ 0101\ 0011\ 0001 \\ \underline{+1} \\ \underbrace{0000}\ \underbrace{0101}\ \underbrace{0011}\ \underbrace{0010} \end{array}$$

Hex twos-complement of FACE → 0 5 3 2

APPENDIX F – HEXADECIMAL AND DECIMAL INTEGER CONVERSION TABLE

8		7		6		5		4		3		2		1	
HEX	DECIMAL	HEX	DECIMAL	HEX	DECIMAL	HEX	DECIMAL	HEX	DECIMAL	HEX	DECIMAL	HEX	DECIMAL	HEX	DECIMAL
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1	268 435 456	1	16 777 216	1	1 048 576	1	65 536	1	4 096	1	256	1	16	1	1
2	536 870 912	2	33 554 432	2	2 097 152	2	131 072	2	8 192	2	512	2	32	2	2
3	805 306 368	3	50 331 648	3	3 145 728	3	196 608	3	12 288	3	768	3	48	3	3
4	1 073 741 824	4	67 108 864	4	4 194 304	4	262 144	4	16 384	4	1 024	4	64	4	4
5	1 342 177 280	5	83 886 080	5	5 242 880	5	327 680	5	20 480	5	1 280	5	80	5	5
6	1 610 612 736	6	100 663 296	6	6 291 456	6	393 216	6	24 576	6	1 536	6	96	6	6
7	1 879 048 192	7	117 440 512	7	7 340 032	7	458 752	7	28 672	7	1 792	7	112	7	7
8	2 147 483 648	8	134 217 728	8	8 388 608	8	524 288	8	32 768	8	2 048	8	128	8	8
9	2 415 919 104	9	150 994 944	9	9 437 184	9	589 824	9	36 864	9	2 304	9	144	9	9
A	2 684 354 560	A	167 772 160	A	10 485 760	A	655 360	A	40 960	A	2 560	A	160	A	10
B	2 952 790 016	B	184 549 376	B	11 534 336	B	720 896	B	45 056	B	2 816	B	176	B	11
C	3 221 225 472	C	201 326 592	C	12 582 912	C	786 432	C	49 152	C	3 072	C	192	C	12
D	3 489 660 928	D	218 103 808	D	13 631 488	D	851 968	D	53 248	D	3 328	D	208	D	13
E	3 758 096 384	E	234 881 024	E	14 680 064	E	917 504	E	57 344	E	3 584	E	224	E	14
F	4 026 531 840	F	251 658 240	F	15 728 640	F	983 040	F	61 440	F	3 840	F	240	F	15
8		7		6		5		4		3		2		1	

TO CONVERT HEXADECIMAL TO DECIMAL

1. Locate the column of decimal numbers corresponding to the left-most digit or letter of the hexadecimal; select from this column and record the number that corresponds to the position of the hexadecimal digit or letter.
2. Repeat step 1 for the next (second from the left) position.
3. Repeat step 1 for the units (third from the left) position.
4. Add the numbers selected from the table to form the decimal number.

TO CONVERT DECIMAL TO HEXADECIMAL

1. (a) Select from the table the highest decimal number that is equal to or less than the number to be converted.
   (b) Record the hexadecimal of the column containing the selected number.
   (c) Subtract the selected decimal from the number to be converted.
2. Using the remainder from step 1(c) repeat all of step 1 to develop the second position of the hexadecimal (and a remainder).
3. Using the remainder from step 2 repeat all of step 1 to develop the units position of the hexadecimal.
4. Combine terms to form the hexadecimal number.

To convert integer numbers greater than the capacity of table, use the techniques below:

HEXADECIMAL TO DECIMAL

Successive cumulative multiplication from left to right, adding units position.

Example: $D34_{16} = 3380_{10}$

$$
\begin{array}{rr}
D = & 13 \\
 & \times 16 \\
\hline
 & 208 \\
3 = & +3 \\
\hline
 & 211 \\
 & \times 16 \\
\hline
 & 3376 \\
4 = & +4 \\
\hline
 & 3380
\end{array}
$$

EXAMPLE	
Conversion of Hexadecimal Value	D34
D	3328
3	48
4	4
Decimal	3380

DECIMAL TO HEXADECIMAL

Divide and collect the remainder in reverse order.

Example: $3380_{10} = D34_{16}$

		remainder
16	3380	4
16	211	3
16	13	D

EXAMPLE	
Conversion of Decimal Value	3380
D	−3328
	52
3	−48
	4
4	−4
Hexadecimal	D34

APPENDIX G – HEXADECIMAL AND DECIMAL FRACTION CONVERSION TABLE

1		2		3		4	
HEX	DECIMAL	HEX	DECIMAL	HEX	DECIMAL	HEX	DECIMAL EQUIVALENT
.0	.0000	.00	.0000 0000	.000	.0000 0000 0000	.0000	.0000 0000 0000 0000
.1	.0625	.01	.0039 0625	.001	.0002 4414 0625	.0001	.0000 1525 8789 0625
.2	.1250	.02	.0078 1250	.002	.0004 8828 1250	.0002	.0000 3051 7578 1250
.3	.1875	.03	.0117 1875	.003	.0007 3242 1875	.0003	.0000 4577 6367 1875
.4	.2500	.04	.0156 2500	.004	.0009 7656 2500	.0004	.0000 6103 5156 2500
.5	.3125	.05	.0195 3125	.005	.0012 2070 3125	.0005	.0000 7629 3945 3125
.6	.3750	.06	.0234 3750	.006	.0014 6484 3750	.0006	.0000 9155 2734 3750
.7	.4375	.07	.0273 4375	.007	.0017 0898 4375	.0007	.0001 0681 1523 4375
.8	.5000	.08	.0312 5000	.008	.0019 5312 5000	.0008	.0001 2207 0312 5000
.9	.5625	.09	.0351 5625	.009	.0021 9726 5625	.0009	.0001 3732 9101 5625
.A	.6250	.0A	.0390 6250	.00A	.0024 4140 6250	.000A	.0001 5258 7890 6250
.B	.6875	.0B	.0429 6875	.00B	.0026 8554 6875	.000B	.0001 6784 6679 6875
.C	.7500	.0C	.0468 7500	.00C	.0029 2968 7500	.000C	.0001 8310 5468 7500
.D	.8125	.0D	.0507 8125	.00D	.0031 7382 8125	.000D	.0001 9836 4257 8125
.E	.8750	.0E	.0546 8750	.00E	.0034 1796 8750	.000E	.0002 1362 3046 8750
.F	.9375	.0F	.0585 9375	.00F	.0036 6210 9375	.000F	.0002 2888 1835 9375
1		2		3		4	

TO CONVERT .ABC HEXADECIMAL TO DECIMAL

Find .A	in position 1	.6250		
Find .0B	in position 2	.0429	6875	
Find .00C	in position 3	.0029	2968	7500
.ABC Hex is equal to		.6708	9843	7500

APPENDIX H – INTEGER CONVERSION TABLE

POWERS OF 16

Example: $268{,}435{,}456_{10} = (2.68435456 \times 10^8)_{10} = 1000\ 0000_{16} = (10^7)_{16}$

16^n							n
						1	0
						16	1
						256	2
					4	096	3
					65	536	4
				1	048	576	5
				16	777	216	6
				268	435	456	7
			4	294	967	296	8
			68	719	476	736	9
		1	099	511	627	776	10 = A
		17	592	186	044	416	11 = B
		281	474	976	710	656	12 = C
	4	503	599	627	370	496	13 = D
	72	057	594	037	927	936	14 = E
1	152	921	504	606	846	976	15 = F

Decimal Values

APPENDIX I – OP CODE INDEX OF INSTRUCTIONS

ALPHANUMERIC SEQUENCE BY HEXADECIMAL

Read down then right.

Mnemonic Assembler Code		AC0	AC1	AC2	AC3	BASE PAGE (XX)	PC REL (XX+PC)	AC2 REL (XX+AC2)	AC3 REL (XX+AC3)									
HALT	0000																	Halt
CFR r		0400	0500	0600	0700													Copy flags to register
CRF r		0800	0900	0A00	0B00													Copy register to flags
PUSHF	0C00																	Push flags onto stack
PULLF	1000																	Pull stack into flags
JSR disp(xr)						14XX	15XX	16XX	17XX									Jump to subroutine; XX = ±127; push PC onto stack
JMP disp(xr)						18XX	19XX	1AXX	1BXX									Jump; XX = ±127
XCHRS r		1C00	1D00	1E00	1F00													Exchange register and stack
ROL r,n,l		20XX	21XX	22XX	23XX													Rotate register left
ROR r,n,l		24XX	25XX	26XX	27XX													Rotate register right — Bit 1 = 1 include link bit
SHL r,n,l		28XX	29XX	2AXX	2BXX													Shift left — Bit 2 = 2 shift count
SHR r,n,l		2CXX	2DXX	2EXX	2FXX													Shift right — Bits 2-7 = N = shift count
fc		NOT USED	IE1	IE2	IE3	IE4	IE5	OVF	CRY	LINK	IEN	BYTE	F11	F12	F13	F14	NOT USED	
PFLG fc		3000	3100	3200	3300	3400	3500	3600	3700	3800	3900	3A00	3B00	3C00	3D00	3E00	3F00	Pulse or reset flag
SFLG fc		3080	3180	3280	3380	3480	3580	3680	3780	3880	3980	3A80	3B80	3C80	3D80	3E80	3F80	Set flag
cc		STACK Full	AC0 = 0	AC0 Bit15=0	AC0 Bit0=1	AC0 Bit1=1	AC0 ≠0	AC0 Bit2=1	CONT	LINK	IEN	CRY	AC0 Bit 15=0	OVF	JC13	JC14	JC15	
BOC cc,disp		40XX	41XX	42XX	43XX	44XX	45XX	46XX	47XX	48XX	49XX	4AXX	4BXX	4CXX	4DXX	4EXX	4FXX	Branch on condition (PC relative) XX = ±127
		AC0	AC1	AC2	AC3													
LI r, disp		50XX	51XX	52XX	53XX													Load immediate; load register with XX; XX = data Bit 7 of XX extends to Bits 8-15 of register
sr dr		AC0 AC0	AC1 AC0	AC2 AC0	AC3 AC0	AC0 AC1	AC1 AC1	AC2 AC1	AC3 AC1	AC0 AC2	AC1 AC2	AC2 AC2	AC3 AC2	AC0 AC3	AC1 AC3	AC2 AC3	AC3 AC3	
RAND sr,dr		5400	5440	5480	54C0	5500	5540	5580	55C0	5600	5640	5680	56C0	5700	5740	5780	57C0	"AND" register to register; result to register (dr)
RXOR sr,dr		5800	5840	5880	58C0	5900	5940	5980	59C0	5A00	5A40	5A80	5AC0	5B00	5B40	5B80	5BC0	Exclusive "OR" register to register; result to register (dr)
RCPY sr,dr		5C00	5C40	5C80	5CC0	5D00	5D40	5D80	5DC0	5E00	5E40	5E80	5EC0	5F00	5F40	5F80	5FC0	Copy register to register
		AC0	AC1	AC2	AC3													
PUSH r		6000	6100	6200	6300													Push register onto stack
PULL r		6400	6500	6600	6700													Pull stack into stack
sr dr		AC0 AC0	AC1 AC0	AC2 AC0	AC3 AC0	AC0 AC1	AC1 AC1	AC2 AC1	AC3 AC1	AC0 AC2	AC1 AC2	AC2 AC2	AC3 AC2	AC0 AC3	AC1 AC3	AC2 AC3	AC3 AC3	
RADD sr,dr		6800	6840	6880	68C0	6900	6940	6980	69C0	6A00	6A40	6A80	6AC0	6B00	6B40	6B80	6BC0	Add register to register; result to register (dr), overflow, and carry
RXCH sr,dr		6C00	6C40	6C80	6CC0	6D00	6D40	6D80	6DC0	6E00	6E40	6E80	6EC0	6F00	6F40	6F80	6FC0	Exchange register
		AC0	AC1	AC2	AC3													
CAI r, disp		70XX	71XX	72XX	73XX													Complement register and add XX; result to register Bit 7 of XX is extended to Bits 8-15
sr dr		AC0 AC0	AC1 AC0	AC2 AC0	AC3 AC0	AC0 AC1	AC1 AC1	AC2 AC1	AC3 AC1	AC0 AC2	AC1 AC2	AC2 AC2	AC3 AC2	AC0 AC3	AC1 AC3	AC2 AC3	AC3 AC3	
RADC sr,dr		7400	7440	7480	74C0	7500	7540	7580	75C0	7600	7640	7680	76C0	7700	7740	7780	77C0	Add register to register plus carry; result to register (dr); overflow and carry

Appendix F

CONVERSION TABLES

Table F-1. Positive Powers of Two

n	2^n				n	2^n						
1	2				51	22517	99813	68524	8			
2	4				52	45035	99627	37049	6			
3	8				53	90071	99254	74099	2			
4	16				54	18014	39850	94819	84			
5	32				55	36028	79701	89639	68			
6	64				56	72057	59403	79279	36			
7	128				57	14411	51880	75855	872			
8	256				58	28823	03761	51711	744			
9	512				59	57646	07523	03423	488			
10	1024				60	11529	21504	60684	6976			
11	2048				61	23058	43009	21369	3952			
12	4096				62	46116	86018	42738	7904			
13	8192				63	92233	72036	85477	5808			
14	16384				64	18446	74407	37095	51616			
15	32768				65	36893	48814	74191	03232			
16	65536				66	73786	97629	48382	06464			
17	13107	2			67	14757	39525	89676	41292	8		
18	26214	4			68	29514	79051	79352	82585	6		
19	52428	8			69	59029	58103	58705	65171	2		
20	10485	76			70	11805	91620	71741	13034	24		
21	20971	52			71	23611	83241	43482	26068	48		
22	41943	04			72	47223	66482	86964	52136	96		
23	83886	08			73	94447	32965	73929	04273	92		
24	16777	216			74	18889	46593	14785	80854	784		
25	33554	432			75	37778	93186	29571	61709	568		
26	67108	864			76	75557	86372	59143	23419	136		
27	13421	7728			77	15111	57274	51828	64683	8272		
28	26843	5456			78	30223	14549	03657	29367	6544		
29	53687	0912			79	60446	29098	07314	58735	3088		
30	10737	41824			80	12089	25819	61462	91747	06176		
31	21474	83648			81	24178	51639	22925	83494	12352		
32	42949	67296			82	48357	03278	45851	66988	24704		
33	85899	34592			83	96714	06556	91703	33976	49408		
34	17179	86918	4		84	19342	81311	38340	66795	29881	6	
35	34359	73836	8		85	38685	62622	76681	33590	59763	2	
36	68719	47673	6		86	77371	25245	53362	67181	19526	4	
37	13743	89534	72		87	15474	25049	10672	53436	23905	28	
38	27487	79069	44		88	30948	50098	21345	06872	47810	56	
39	54975	58138	88		89	61897	00196	42690	13744	95621	12	
40	10995	11627	776		90	12379	40039	28538	02748	99124	224	
41	21990	23255	552		91	24758	80078	57076	05497	98248	448	
42	43980	46511	104		92	49517	60157	14152	10995	96496	896	
43	87960	93022	208		93	99035	20314	28304	21991	92993	792	
44	17592	18604	4416		94	19807	04062	85660	84398	38598	7584	
45	35184	37208	8832		95	39614	08125	71321	68796	77197	5168	
46	70368	74417	7664		96	79228	16251	42643	37593	54395	0336	
47	14073	74883	55328		97	15845	63250	28528	67518	70879	00672	
48	28147	49767	10656		98	31691	26500	57057	35037	41758	01344	
49	56294	99534	21312		99	63382	53001	14114	70074	83516	02688	
50	11258	99906	84262	4	100	12676	50600	22822	94014	96703	20537	6
					101	25353	01200	45645	88029	93406	41075	2

Table F-2. Negative Powers of Two

n	2^{-n}									
0	1.0									
1	0.5									
2	0.25									
3	0.125									
4	0.0625									
5	0.03125									
6	0.01562	5								
7	0.00781	25								
8	0.00390	625								
9	0.00195	3125								
10	0.00097	65625								
11	0.00048	82812	5							
12	0.00024	41406	25							
13	0.00012	20703	125							
14	0.00006	10351	5625							
15	0.00003	05175	78125							
16	0.00001	52587	89062	5						
17	0.00000	76293	94531	25						
18	0.00000	38146	97265	625						
19	0.00000	19073	48632	8125						
20	0.00000	09536	74316	40625						
21	0.00000	04768	37158	20312	5					
22	0.00000	02384	18579	10156	25					
23	0.00000	01192	09289	55078	125					
24	0.00000	00596	04644	77539	0625					
25	0.00000	00298	02322	38769	53125					
26	0.00000	00149	01161	19384	76562	5				
27	0.00000	00074	50580	59692	38281	25				
28	0.00000	00037	25290	29846	19140	625				
29	0.00000	00018	62645	14923	09570	3125				
30	0.00000	00009	31322	57461	54785	15625				
31	0.00000	00004	65661	28730	77392	57812	5			
32	0.00000	00002	32830	64365	38696	28906	25			
33	0.00000	00001	16415	32182	69348	14453	125			
34	0.00000	00000	58207	66091	34674	07226	5625			
35	0.00000	00000	29103	83045	67337	03613	28125			
36	0.00000	00000	14551	91522	83668	51806	64062	5		
37	0.00000	00000	07275	95761	41834	25903	32031	25		
38	0.00000	00000	03637	97880	70917	12951	66015	625		
39	0.00000	00000	01818	98940	35458	56475	83007	8125		
40	0.00000	00000	00909	49470	17729	28237	91503	90625		
41	0.00000	00000	00454	74735	08864	64118	95751	95312	5	
42	0.00000	00000	00227	37367	54432	32059	47875	97656	25	
43	0.00000	00000	00113	68683	77216	16029	73937	98828	125	
44	0.00000	00000	00056	84341	88608	08014	86968	99414	0625	
45	0.00000	00000	00028	43170	94304	04007	43484	49707	03125	
46	0.00000	00000	00014	21085	47152	02003	71742	24853	51562	5
47	0.00000	00000	00007	10542	73576	01001	85871	12426	75781	25
48	0.00000	00000	00003	55271	36788	00500	92935	56213	37890	625
49	0.00000	00000	00001	77635	68394	00250	46467	78106	68945	3125
50	0.00000	00000	00000	88817	84197	00125	23233	89053	34472	65625

Table F-3. Integer Conversion Table

POWERS OF 16

Example: $268{,}435{,}456_{10} = (2.68435456 \times 10^{8})_{10} = 1000\ 0000_{16} = (10^{7})_{16}$

16^n							n
						1	0
						16	1
						256	2
					4	096	3
					65	536	4
				1	048	576	5
				16	777	216	6
				268	435	456	7
			4	294	967	296	8
			68	719	476	736	9
		1	099	511	627	776	10 = A
		17	592	186	044	416	11 = B
		281	474	976	710	656	12 = C
	4	503	599	627	370	496	13 = D
	72	057	594	037	927	936	14 = E
1	152	921	504	606	846	976	15 = F

Decimal Values

The SC/MP microprocessor maintains negative numbers in twos-complement form. To convert a number in hexadecimal notation to its twos-complement equivalent, subtract the number from hexadecimal 2^n, where "n" is the number of binary bits in the computer word. For an 8-bit byte, "n" is 8, and 2^n is 1 0000 0000 (binary) or 100 (hex).

Thus, the negative of 1C is:

$$\begin{array}{r} 100 \\ \underline{1C} \\ E4 \end{array}$$

A hexadecimal number will be negative in the SC/MP microprocessor if the left-most digit is 8, 9, A, B, C, D, E, or F (because all of these groupings start with a one). Thus, the twos-complement of C7 is

$$\begin{array}{r} 100 \\ \underline{C7} \\ 39 \end{array}$$

Perhaps an easier way to find the twos-complement of a hexadecimal number is first to take the ones-complement of the number; the ones-complement plus one is the twos-complement. The ones-complement of a number is its inverted form; simply exchange its ones for zeros, and its zeros for ones. Thus,

hexadecimal	binary equivalent	ones-complement
C7	1100 0111	0011 1000

ones-complement + 1

$$\begin{array}{r} 0011\ 1000 \\ \underline{+1} \\ \underbrace{0011}_{3}\ \underbrace{1001}_{9} \end{array}$$

Hex twos-complement of C7 → 3 9

Table F-4. Hexadecimal and Decimal Fraction Conversion

1		2		3		4	
HEX	DECIMAL	HEX	DECIMAL	HEX	DECIMAL	HEX	DECIMAL EQUIVALENT
.0	.0000	.00	.0000 0000	.000	.0000 0000 0000	.0000	.0000 0000 0000 0000
.1	.0625	.01	.0039 0625	.001	.0002 4414 0625	.0001	.0000 1525 8789 0625
.2	.1250	.02	.0078 1250	.002	.0004 8828 1250	.0002	.0000 3051 7578 1250
.3	.1875	.03	.0117 1875	.003	.0007 3242 1875	.0003	.0000 4577 6367 1875
.4	.2500	.04	.0156 2500	.004	.0009 7656 2500	.0004	.0000 6103 5156 2500
.5	.3125	.05	.0195 3125	.005	.0012 2070 3125	.0005	.0000 7629 3945 3125
.6	.3750	.06	.0234 3750	.006	.0014 6484 3750	.0006	.0000 9155 2734 3750
.7	.4375	.07	.0273 4375	.007	.0017 0898 4375	.0007	.0001 0681 1523 4375
.8	.5000	.08	.0312 5000	.008	.0019 5312 5000	.0008	.0001 2207 0312 5000
.9	.5625	.09	.0351 5625	.009	.0021 9726 5625	.0009	.0001 3732 9101 5625
.A	.6250	.0A	.0390 6250	.00A	.0024 4140 6250	.000A	.0001 5258 7890 6250
.B	.6875	.0B	.0429 6875	.00B	.0026 8554 6875	.000B	.0001 6784 6679 6875
.C	.7500	.0C	.0468 7500	.00C	.0029 2968 7500	.000C	.0001 8310 5468 7500
.D	.8125	.0D	.0507 8125	.00D	.0031 7382 8125	.000D	.0001 9836 4257 8125
.E	.8750	.0E	.0546 8750	.00E	.0034 1796 8750	.000E	.0002 1362 3046 8750
.F	.9375	.0F	.0585 9375	.00F	.0036 6210 9375	.000F	.0002 2888 1835 9375
1		2		3		4	

TO CONVERT .ABC HEXADECIMAL TO DECIMAL

Find .A	in position 1	.6250
Find .0B	in position 2	.0429 6875
Find .00C	in position 3	.0029 2968 7500
.ABC Hex is equal to		.6708 9843 7500

Table F-5. Hexadecimal and Decimal Integer Conversion

8		7		6		5		4		3		2		1	
HEX	DECIMAL	HEX	DECIMAL	HEX	DECIMAL	HEX	DECIMAL	HEX	DECIMAL	HEX	DECIMAL	HEX	DECIMAL	HEX	DECIMAL
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1	268 435 456	1	16 777 216	1	1 048 576	1	65 536	1	4 096	1	256	1	16	1	1
2	536 870 912	2	33 554 432	2	2 097 152	2	131 072	2	8 192	2	512	2	32	2	2
3	805 306 368	3	50 331 648	3	3 145 728	3	196 608	3	12 288	3	768	3	48	3	3
4	1 073 741 824	4	67 108 864	4	4 194 304	4	262 144	4	16 384	4	1 024	4	64	4	4
5	1 342 177 280	5	83 886 080	5	5 242 880	5	327 680	5	20 480	5	1 280	5	80	5	5
6	1 610 612 736	6	100 663 296	6	6 291 456	6	393 216	6	24 576	6	1 536	6	96	6	6
7	1 879 048 192	7	117 440 512	7	7 340 032	7	458 752	7	28 672	7	1 792	7	112	7	7
8	2 147 483 648	8	134 217 728	8	8 388 608	8	524 288	8	32 768	8	2 048	8	128	8	8
9	2 415 919 104	9	150 994 944	9	9 437 184	9	589 824	9	36 864	9	2 304	9	144	9	9
A	2 684 354 560	A	167 772 160	A	10 485 760	A	655 360	A	40 960	A	2 560	A	160	A	10
B	2 952 790 016	B	184 549 376	B	11 534 336	B	720 896	B	45 056	B	2 816	B	176	B	11
C	3 221 225 472	C	201 326 592	C	12 582 912	C	786 432	C	49 152	C	3 072	C	192	C	12
D	3 489 660 928	D	218 103 808	D	13 631 488	D	851 968	D	53 248	D	3 328	D	208	D	13
E	3 758 096 384	E	234 881 024	E	14 680 064	E	917 504	E	57 344	E	3 584	E	224	E	14
F	4 026 531 840	F	251 658 240	F	15 728 640	F	983 040	F	61 440	F	3 840	F	240	F	15
8		7		6		5		4		3		2		1	

TO CONVERT HEXADECIMAL TO DECIMAL

1. Locate the column of decimal numbers corresponding to the left-most digit or letter of the hexadecimal; select from this column and record the number that corresponds to the position of the hexadecimal digit or letter.
2. Repeat step 1 for the next (second from the left) position.
3. Repeat step 1 for the units (third from the left) position.
4. Add the numbers selected from the table to form the decimal number.

TO CONVERT DECIMAL TO HEXADECIMAL

1. (a) Select from the table the highest decimal number that is equal to or less than the number to be converted.
   (b) Record the hexadecimal of the column containing the selected number.
   (c) Subtract the selected decimal from the number to be converted.
2. Using the remainder from step 1(c) repeat all of step 1 to develop the second position of the hexadecimal (and a remainder).
3. Using the remainder from step 2 repeat all of step 1 to develop the units position of the hexadecimal.
4. Combine terms to form the hexadecimal number.

To convert integer numbers greater than the capacity of table, use the techniques below:

HEXADECIMAL TO DECIMAL

Successive cumulative multiplication from left to right, adding units position.

Example: $D34_{16} = 3380_{10}$

D =	13
	x16
	208
3 =	+3
	211
	x16
	3376
4 =	+4
	3380

EXAMPLE

Conversion of Hexadecimal Value	D34
D	3328
3	48
4	4
Decimal	3380

DECIMAL TO HEXADECIMAL

Divide and collect the remainder in reverse order.

Example: $3380_{10} = D34_{16}$

		remainder
16	3380	4
16	211	3
16	13	D

EXAMPLE

Conversion of Decimal Value	3380
D	−3328
	52
3	−48
	4
4	−4
Hexadecimal	D34

COURSE GRADE - A

FINAL EXAM-INTRO TO DATA COMM-UC IRVINE-5 December 1987/Name LUCAS

93

1-What are the 2 primary processes which can be used to increase the data carrying capacity of a communications line?

-2

A- DATA COMPRESSION

B- MULTIPLEXING

2-What are the three primary forms of analog modulation and the one primary form of digital modulation?

Analog- A- AMPLITUDE B- FREQUENCY C- PHASE

Digital- A- PULSE AMPLITUDE

3-What is the single most important factor for using a multiplexer?

TO REDUCE AMOUNT OF LINES - (COMBINES SEVERAL SLOW LINES TO ONE HI-SPEED LINE)

4-What are the three ways to handle errors when received on a communications line?

A- FLAG THE ERROR AT RECEIVING END

B- DETECT AND REQUEST A RETRANSMISSION

C- FORWARD ERROR CORRECTION

5-On a PBX what does the term "blocking" mean?

MORE IN HOUSE CONNECTIONS TO THE PBX THAN THERE ARE CIRCUITS AVAILABLE

6-List 4 factors to consider when comparing a PBX with Centrex.

CENTREX

MAINTENANCE — PHONE CO. RESPONSIBILITY

OPEN 24 HRS — MORE EXPENSIVE (COST/LINE)

7-What is the operational difference between a standard Time Division Multiplexer and a Statistical Time Division Multiplexer?

STAMUX TRANSMISSIONS CAN SUPPORT MANY MORE LOW SPEED LINES - TRANSMISSION EFFICIENCY

8-What 2 parameters does the signal constellation of a modem represent?

A- AMPLITUDE B- PHASE

9-What kind of function does the 56 bit DES perform?

PART OF AN ENCRYPTION ALGORITHM

10-What do the following specifications describe?

X.3- PACKET ASSEMBLY/DISSASSEMBLY FACILITY IN PUBLIC N

X.28- DTE/DCE INTERFACE FOR START/STOP MODE DATA TERMINA ACCESSING THE "PAD" ON A NET IN SAME COUNTRY

X.29- PROCEDURES FOR EXCHANGE OF CONTROL INFO. AND USER DATA BETWEEN PACKET MODE DTE AND PAD

X.25- INTERFACE BETWEEN DATA TERMINAL AND DATA CIRCUIT TERMINATION FOR TERMINALS IN PACKET MODE

11-Regarding the billing criteria for packet switching. It is based on

QUANTITY OF PACKETS instead of TIME and DISTANCE

12-What is CSMA/CD and what kind of LAN is it used on?

CSMA/CD "CARRIER SENSE MULTIPLE ACCESS/COLLISION DETECTION

Kind of LAN used on CONTENTION BUS MODE (ETHERNET)

13-From a data communications viewpoint, what is the most serious drawback of satellite transmission?

PROPAGATION DELAY

14-What are 4 factors that are different between a Narrowband LAN and a Wideband LAN?

A- DISTANCE

B- EFFICIENCY

C- COST

D- CARRYING CAPACITY

15-What is DB a measurement of?

POWER ~~RATIOS~~

16-What does C type line conditioning do?

A- ATTENUATION DISTORTION

B- ENVELOPE DELAY DISTORTION

17-In ISDN what does the device called a Terminal Adapter do?

CONVERTS THE RS232 SIGNALS TO THE ISDN INTERFACE SIGNALS AND IS WITHIN THE NT-2.

18-What is the primary reason for utilizing Bipolar signalling in digital transmission?

ANALOG N/W

-4 PULSES OCCUR ONLY WHEN THE SIGNAL CONTAINS "1" BITS; AND THEY ALTERNATE IN POLARITY

19-What is the primary function of the 193rd bit in T-1 framing format?

THE FRAME IS 193 BITS LONG

THE 193rd BIT IS THE "FRAMING BIT"

20-In ISDN - What does the B channel carry? 64 KBPS OF INFORMATION

What does the D channel carry? 16 KBPS CONTROL OR SIGNALING
OR 64KBPS

21-What are the 3 primary areas to consider for network backup?

A- POWER BACK-UP B- SPARE LINES

C- SPARE MODEMS SAME IDEA

22-In ISDN what is the numeric or alphanumeric definition of-

Basic Rate Access 2B+D

Primary Rate Access 23B+D

23-What 4 entities can be described as half duplex or full duplex?

A- CIRCUITS B- PROTOCOLS

C- MODEMS D- ECHOPLEX

24-What is the single biggest problem that prevents telephone companies from providing Packet Switching services and/or ISDN between different states?

COMPATABILITY BETWEEN DIFFERENT LOCATIONS

25-What 4 major functions do you want your Network Management System to perform for you?

A- MONITOR PHYSICAL STATUS & HARDWARE, PERSONNEL, ETC.

B- MONITOR PERFORMANCE: EFFICIENCY, RESPONSE TIME, ETC.

C- NETWORK CONTROL: IDENTIFY PROBLEM AND CORRECT IT

D- MONITOR & CONTROL OF NETWORK OPERATIONS.

FINAL EXAM-INTRO TO DATA COMM-UC IRVINE-5 December 1987/Name__________

1-What are the 2 primary processes which can be used to increase the data carrying capacity of a communications line?

A- FASTER TRANSMISSION SPEED

B- DATA COMPRESSION

2-What are the three primary forms of analog modulation and the one primary form of digital modulation?

Analog- A- FM/FSK B- AM C- PM/PSK

Digital- A- PCM/PAM(ok)

3-What is the single most important factor for using a multiplexer?

SAVING LINE COSTS

4-What are the three ways to handle errors when received on a communications line?

A- FLAG THEM AT RECEIVE END

B- REQUEST A RETRANSMISSION

C- FORWARD ERROR CORRECTION

5-On a PBX what does the term "blocking" mean?

WHEN YOU PICK UP THE TELEPHONE HANDSET THERE IS A FINITE PROBABILITY YOU WONT GET A DIAL TONE

6-List 4 factors to consider when comparing a PBX with Centrex.

SPACE   COST   MAINTENANCE
POWER   FEATURES   FLEXIBILITY
EASE OF ADDING NEW CAPABILITY

7-What is the operational difference between a standard Time Division Multiplexer and a Statistical Time Division Multiplexer?

STANDARD TDM HAS A DEDICATED SLOT FOR EACH LO SPD LINE AND STAT MUX ALLOCATES HI SPD CAPACITY AS REQUIRED

8-What 2 parameters does the signal constellation of a modem represent?

A- AMPLITUDE OF CARRIER B- PHASE OF CARRIER

9-What kind of function does the 56 bit DES perform?

ENCRYPTION

10-What do the following specifications describe?

X.3- LOW SPEED ASYNCHRONOUS PAD FOR PACKET NETWORKS

X.28- TERMINAL PARAMETERS FOR LO SPD (TTY) TYPE TERMINAL

X.29- CONTROLS BETWEEN HOST AND X.3 PAD

X.25- HI SPEED SYNCHRONOUS INTERFACE (PAD) FOR PACKET NETWOR

11-Regarding the billing criteria for packet switching. It is based on

VOLUME instead of TIME and DISTANCE

12-What is CSMA/CD and what kind of LAN is it used on?

CSMA/CD CARRIER SENSE MULTIPLE ACCESS/COLLISION DETECTION
OR A METHOD FOR ACCESSING THE MEDIUM ON 1 TYPE OF LAN

Kind of LAN used on ETHERNET - STARLAN

13-From a data communications viewpoint, what is the most serious drawback of satellite transmission?

PROPAGATION DELAY

14-What are 4 factors that are different between a Narrowband LAN and a Wideband LAN?

A- SPEED B- COST

C- CAPACITY D- TYPES OF APPS. SUPPORTED

TYPES OF MEDIA USED QUANTITY OF USERS AT 1 TIME

15-What is DB a measurement of?

POWER

16-What does C type line conditioning do?

A- IMPROVE ATTENUATION DISTORTION

B- IMPROVE ENVELOPE DELAY

17-In ISDN what does the device called a Terminal Adapter do?

MAKES A NON ISDN COMPATIBLE DEVICE
COMPATIBLE WITH ISDN. OR RS232 TO ISDN (2B+D)

18-What is the primary reason for utilizing Bipolar signalling in digital transmission?

TRANSMISSION IS ON EXISTING ANALOG FACILITIES
SOMETIMES AND THEY HAVE INDUCTANCES WHICH CANNOT
SUPPORT SIGNALS WITH 1 DIRECTION OF SIGNAL POLARITY

19-What is the primary function of the 193rd bit in T-1 framing format?

FRAME SYNCHRONIZATION

20-In ISDN - What does the B channel carry? INFORMATION

What does the D channel carry? CONTROL SIGNALS (SOMETIMES DATA ALSO)

21-What are the 3 primary areas to consider for network backup?

A- COMMUNICATIONS B- DISASTER

C- POWER

22-In ISDN what is the numeric or alphanumeric definition of-

Basic Rate Access 2B+D (144KBPS)

Primary Rate Access 23B+D (1.544MBPS)

23-What 4 entities can be described as half duplex or full duplex?

A- CIRCUIT B- MODEM

C- PROTOCOL D- ECHOPLEX

24-What is the single biggest problem that prevents telephone companies from providing Packet Switching services and/or ISDN between different states?

DIFFERENT INTERFACES BETWEEN LOCAL & LONG DISTANCE TELCOS.

25-What 4 major functions do you want your Network Management System to perform for you?

A- MONITOR PHYSICAL STATUS (HARDWARE, FACILITIES, ETC)

B- MONITOR PERFORMANCE (UTILIZATION, TRAFFIC, ETC)

C- N/W CONTROL (FIND & FIX PROBLEMS)

D- N/W MGMT (GROWTH, CHANGES, OPTIMIZATION, ETC)

INTRODUCTION TO DATA COMMUNICATIONS
MIDTERM-UCI Extension-Monday Night-26 October 1987

1-Draw a diagram of the major elements of a Host computer and how the various networks connect to it.

2-Identify 5 types of communications carriers and their types of services

3-Identify 5 types of communications media and where they might be used.

4-What are the four definitions of half duplex and full duplex.

5-What is the primary difference between synchronous and asynchronous communications methods.

6-Name three forms of data that can be transmitted synchronously but not asynchronously.

7-From a communications point of view, what is the difference between ASCII and EBCDIC codes.

8-Show three configurations of hardware that allow a PC to talk to a mainframe synchronously.

9-Name the 7 layers of the ISO protocol and what their function is.

10-What is the difference between BPS and Baud.

11-Define a poll and call.

12-What are the 3 elements that make up a tariff.

13-What organizations rule on tariffs and in what jurisdiction.

14-What 2 methods are allowed to connect devices to a telephone line.

15-What is a LATA and what does it provide.

16-What is the T-1 transmission rate and how is it derived.

PAGE 48

17-Describe the sequence of operations that a multistation controller uses to move data to and from a communications front end.

18-What does a flow control protocol do. Give three examples.

19-Describe the operation of 3 types of ARQ protocols.

20-What are 4 other names for a leased line.

21-What is the difference in usage between RS232 and a local area network

22-What does RTS/CTS delay mean.

23-What is the difference between a foreign exchange line and a tie line.

24-What must you be careful of when you tie 2 terminal devices together for the first time.

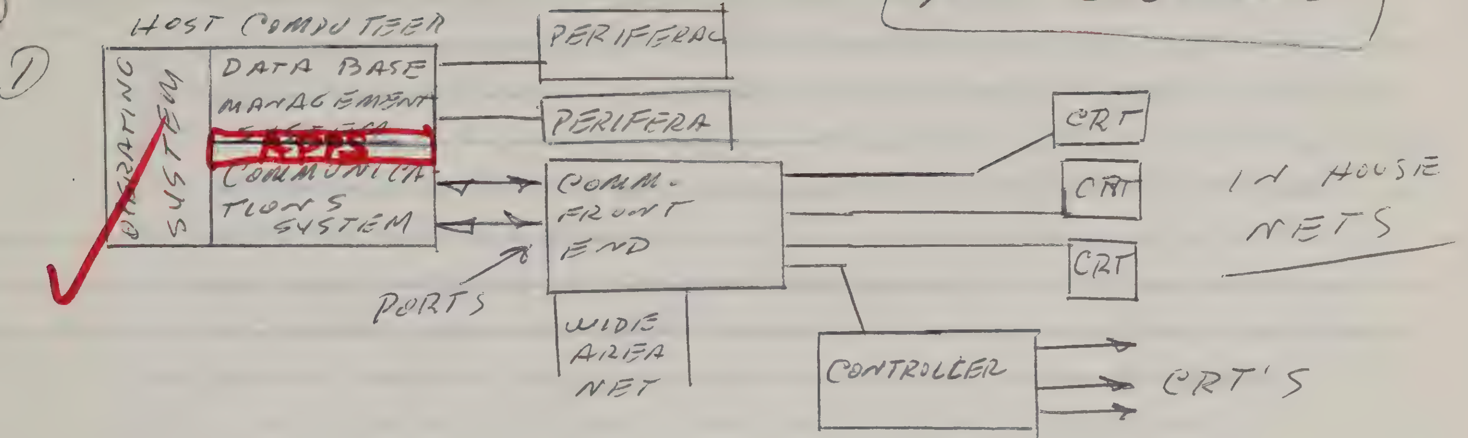
25-What 2 attributes of the class do you like most so far and what 2 do you like least (full credit regardless of how you answer).

90-100 - A
80-89 - B EC

① -

(28) ADD +7

A- LUCAS

1) 

2) a. LOCAL CARRIER: LOCAL PHONE CO. PROVIDES CONNECTION FROM CONSUMER TO NETWORKS
b. LONG DISTANCE CARRIER: PROVIDE INTRASTATE AND INTERSTATE CONNECTIONS.
c. SATELLITE CARRIERS: LONG DISTANCE CARRIES THAT USE SATELLITE CKTS FOR COMMUNICATIONS BETWEEN LOCATIONS - MANLY USED FOR VOICE OR LOW DATARATE.
d. RADIO CARRIERS: USED MAINLY FOR MOBILE COMMUNICATIONS - (CELLULAR SYSTEMS)
e. VALUE ADDED NETWORK: PACKET SWITCHING - PROVIDES EXTRA SERVICES SUCH AS MESSAGE VALIDATION.

3) a. TWISTED PAIR: LOCAL
b. COAX CABLE: LOCAL AREA AND CROSS COUNTRY
c. FIBER CABLE: LOCAL BUSSINES, INTRACITY, INTERCITY.
d. MICROWAVE: TERRESTIAL, SATELLITE
e. RADIO SYSTEMS - BROADCAST, BEAM AND SATELLITE

4) a - HALF DUPLEX: TWO WIRE SYSTEM - POINT TO POINT
b - HALF DUPLEX: TWO WIRE SYSTEM - MASTER TO SEVERAL POINTS.
3 c. FULL DUPLEX: 4 WIRE SYSTEM: POINT TO POINT
d. FULL DUPLEX: 4 WIRE SYSTEM: MULTIPOINT - MULTISTATION

CIRCUIT/PROTOCOL/MODEM/ECHOPLEX

② A-LUCAS

(5) SYNCHRONOUS COMMUNICATIONS REQUIRES A CLOCK SIGNAL FOR SYNCHRONIZATION OF RECEIVER TO DATA - MESSAGE FRAMED DATA, USES A START SEQUENCE AND END SEQUENCE FOR MESSAGE. SYNC CHARACTERS SENT AT BEGINNING OF TRANSMISSION

ASYNCHRONOUS COMMUNICATION: CHARACTER FRAME DATA - NO SYNC CLOCK - USES START AND STOP BITS TO FRAM CHARACTER.

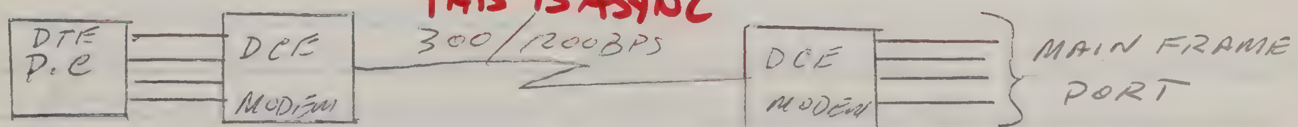
(6) -3 HIGH SPEED TRANSMISSION OVER 2400 BPS - ANALOG OR DIGITAL MUST BE IN SYNCHRONOUS FORM.

GRAPHIC BINARY STREAM COMPRESSED ENCRYPTED

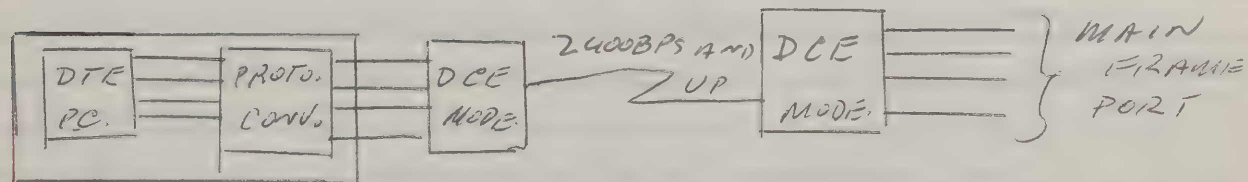
(7) EBCDIC CODES HAS NO BITS SET ASIDE FOR PARITY DETECTION

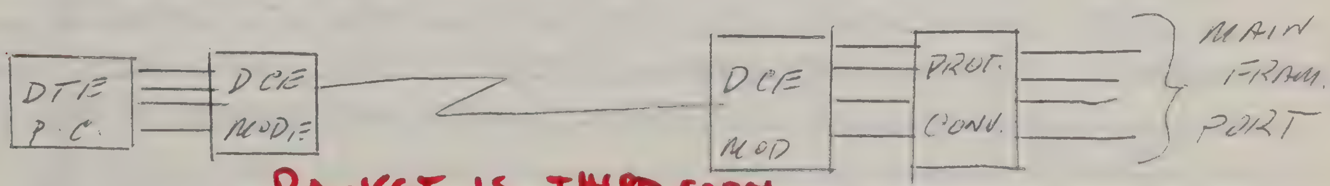
(8)

THIS IS ASYNC



-1





PACKET IS THIRD FORM

(9) LAYER 1: PHYSICAL LAYER - DEFINES FUNCTIONS REQUIRED TO ACTIVATE, MAINTAIN AND DE-ACTIVATE THE PHYSICAL CONNECTION.

LAYER 2: DATALINK - MECHANISM FOR SYNCHRONIZING AND ERROR CONTROL.

LAYER 3: NETWORK: PROVIDES SWITCHING AND ROUTING FUNCTIONS TO STABLISH, MAINTAIN AND TERMINATE CONNECTIONS

9-CONTIN.

LAYER 4: TRANSPORT: PROVIDES END TO END CONTROL FOR INFO. INTERCHANGE AT THE RELIABILITY REQUIRED.

LAYER 5: SESSION: PROVIDES NECESSARY INTERFACE TO SUPPORT THE DIALOG BETWEEN TWO SEPARATE APPLICATIONS.

LAYER 6: PRESENTATION: INSURES THAT THE INFORMATION IS DELIVERED IN A FORM THAT THE RECEIVING SYSTEM CAN UNDERSTAND AND USE

LAYER 7: APPLICATION: SUPPORTS THE END USERS APPLICATION.

(10) BPS = BITS PER SECOND = DATA RATE GIVEN IN BITS PER SECOND - ACTUAL INFORMATION FLOW
BAUD: SIGNAL CHANGE RATE ON THE LINE.

(11) - POLL: A CONTROL MESSAGE SENT BY A MASTER TO A SLAVE SITE. INVITATION TO SLAVE TO COMMUNICATE WITH MASTER.
CALL: A CONTROL MESSAGE SENT BY A MASTER TO A SLAVE SITE TO BE READY TO RECEIVE.

(12) - IDENTITY OF SERVICES TO BE PROVIDED, CHARGES FOR THOSE SERVICES AND LIABILITIES OF CARRIER AND USER

(13) FCC FOR SERVICES BETWEEN TWO OR MORE STATES.
PUC FOR SERVICES WITHIN A SINGLE STATE

(14) BY MEANS OF "DATA ACCESS ARRANGEMENT" AND EQUIPMENT THAT IS REGISTERED AND CERTIFIED

(15) - LATA; LOCAL ACCESS AND TRANSPORT AREA - LOCAL TELEPHONE CO GEOGRAPHICAL SUBDIVISION.

(4) A- LUCAS

(16) 3 T1 = 1.544 MBPS.
24 FRAMES @ 192 BITS @a 8000 FRAMES + 1 FRAMING BIT

(17) 4 POLL →
← MSG
ACK →

CALL →
← ACK
MSG →
← ACK

(18) 4 STOPS XMTR FROM TRANSMITTING
X_{ON}/X_{OFF} ETX/ACK
DTR ON/OFF

X = ON X = OF
X R -

(19) STOP AND WAIT: ONE BLOCK IS SENT AT A TIME. MUST WAIT FOR ACKNOWLEDGEMENT BEFORE NEXT BLOCK IS SENT.
CONTINOUS: 5 BLOCKS ARE SENT THEN AN ACKNOWLEDGEMENT FOR THE SIX IS SENT.
SELECTIVE REJECT: A NAK MESSAGE IS RETURNED IF AN ERROR IS RECEIVED IN ANY BLOCK - THE BLOCK IS IDENTIFIED AND RETRANSMITTED

(20) -2 ~~2~~ LEASED LINE, PRIVATE LINE, DEDICATED LINE, ~~TIE LINE, FOREIGN EXCHANGE LINE~~
3002, DATA

(21) -2 LAN OR ETHERNET ALLOWS FOR TRANSMISSION OF DATA UP TO 10 MBPS. RS232 PT-PT
DC
LAN MULTIPLE DEVICES

(22) MODEM TURN AROUND TIME - DELAY BETWEEN REQUEST TO SEND AND CLEAR TO SEND

(23) "TIE" LINE - LEASED LINE THAT CONNECTS TWO PBX SO THAT A CALL CAN BE MADE DIRECTLY.
"FEX" LINE LEASED LINE THAT PROVIDES ONE EXCHANGE TO CALL ANOTHER EXCHANGE AS A LOCAL CALL WHERE NORMALLY IS A TOLL CALL.

A. LUCAS

(24) THE RECEIVE AND TRANSMIT LINES MUST BE CONNECTED TO THE RIGHT CKTS - ASIDE FROM ALL OTHER CONNECTIONS BEING PROPERLY MADE - PROTOCOLS/CODE SETS/ETC

(25). I ENJOY THE SUBJECT VERY MUCH. IT IS MOSTLY NEW TO ME.

I DON'T SEEM TO HAVE ENOUGH TIME TO ABSORB ALL OF IT - SOME SECTIONS WE DID NOT SPEND ENOUGH TIME ON IN CLASS.

RS-449 | EIA-530

RS-449 SIGNAL NAME	EIA NAME	CCITT NAME	PIN NUMBER	PIN NUMBER	CCITT NAME	EIA NAME	EIA-530 SIGNAL NAME
SHIELD	–	–	1	1	–	–	SHIELD
SEND DATA	SD(A)	103	4	2	103	BA(A)	TRANSMITTED DATA
	SD(B)		22	14		BA(B)	
RECEIVE DATA	RD(A)	104	6	3	104	BB(A)	RECEIVED DATA
	RD(B)		24	16		BB(B)	
REQUEST TO SEND	RS(A)	105	7	4	105	CA(A)	REQUEST TO SEND
	RS(B)		25	19		CA(B)	
CLEAR TO SEND	CS(A)	106	9	5	106	CB(A)	CLEAR TO SEND
	CS(B)		27	13		CB(B)	
DATA MODE	DM(A)	107	11	6	107	CC(A)	DCE READY
	DM(B)		29	22		CC(B)	
TERMINAL READY	TR(A)	108	12	20	108	CD(A)	DTE READY
	TR(B)		30	23		CD(B)	
SIGNAL GROUND	SG	102	19	7	102	AB	SIGNAL GROUND
RECEIVER READY	RR(A)	109	13	8	109	CF(A)	RECEIVED LINE SIGNAL
	RR(B)		31	10		CF(B)	DETECT (CARRIER DETECT)
SEND TIMING	ST(A)	114	5	15	114	DB(A)	TRANSMIT SIGNAL ELEMENT
	ST(B)		23	12		DB(B)	TIMING - DCE SOURCE
RECEIVE TIMING	RT(A)	115	8	17	115	DD(A)	RECEIVER SIGNAL ELEMENT
	RT(B)		26	9		DD(B)	TIMING - DCE SOURCE
LOCAL LOOPBACK	LL	141	10	18	141	LL	LOCAL LOOPBACK
REMOTE LOOPBACK	RL	140	14	21	140	RL	REMOTE LOOPBACK
TERMINAL TIMING	TT(A)	113	17	24	113	DA(A)	TRANSMIT SIGNAL ELEMENT
	TT(B)		35	11		DA(B)	TIMING - DTE SOURCE
TEST MODE	TM	142	18	25	142	TM	TEST MODE
SEND COMMON	SC	102A	37				NOT USED
RECEIVE COMMON	RC	102B	20				NOT USED
TERMINAL INSERVICE	IS	135	28				NOT USED
INCOMING CALL	IC	125	15				NOT USED
SIGNAL QUALITY	SQ	110	33				NOT USED
NEW SIGNAL	NS	136	34				NOT USED
SIGNALLING RATE INDICATOR	SI	112	2				NOT USED
SELECT FREQUENCY/	SF/	126/	16				NOT USED
SIGNAL RATE SELECTOR	SR	111	32				NOT USED
SELECT STANDBY	SS	116	36				NOT USED
STANDBY INDICATOR	SB	117	3,21				NOT USED
SPARES							

EIA

RS 232 C

PIN #	CCITT CKT NAME	EIA 232C CKT NAME	DIRECTION	NAME
1	101	AA	BOTH	PROTECTIVE GROUND
7	102	AB	BOTH	SIGNAL GROUND
2	103	BA	To-DCE	TRANSMIT DATA
3	104	BB	To-DTE	RECEIVE DATA
4	105	CA	To-DCE	REQUEST TO SEND
5	106	CB	To-DTE	CLEAR TO SEND
6	107	CC	To-DTE	MODEM READY
20	108.2	CD	To-DCE	TERMINAL READY
22	125	CE	To-DTE	RING INDICATOR
8	109	CF	To-DTE	RCV. LINE SIGNAL DETECT (CARRIER DETECT)
21	110	CG	To-DTE	SIGNAL QUALITY DETECTOR
23	111/ 112	CH/ CI	Either	DATA SIGNALLING RATE SELECTOR/INDICATOR
24	113	DA	To-DCE	TRANSMIT CLOCK - DTE SOURCE
15	114	DB	To-DTE	TRANSMIT CLOCK - DCE SOURCE
17	115	DD	To-DTE	RECEIVE CLOCK - DCE SOURCE
14	118	SBA	To-DCE	SECONDARY TRANSMIT DATA
16	119	SBB	To-DTE	SECONDARY RECEIVE DATA
19	120	SCA	To-DCE	SECONDARY REQUEST TO SEND
13	121	SCB	To-DTE	SECONDARY CLEAR TO SEND
12	122	SCF	To-DTE	SECONDARY CARRIER DETECT

RS 232 D

PIN #	CCITT CKT NAME	EIA 232C CKT NAME	DIRECTION	NAME
1				SHIELD
7	102	AB	BOTH	SIGNAL GROUND/COMMON RETURN
2	103	BA	To-DCE	TRANSMIT DATA
3	104	BB	To-DTE	RECEIVE DATA
4	105	CA	To-DCE	REQUEST TO SEND
5	106	CB	To-DTE	CLEAR TO SEND
6	107	CC	To-DTE	DCE READY
20	108.2	CD	To-DCE	DTE READY
22	125	CE	To-DTE	RING INDICATOR
8	109	CF	To-DTE	RCV. LINE SIGNAL DETECT CARRIER DETECT
21	140/ 110	RL/ CG	To-DTE	REMOTE LOOPBACK/ SIGNAL QUALITY DETECTOR*
23	111/ 112	CH/ CI	Either	DATA SIGNALLING RATE SELECTOR/INDICATOR**
24	113	DA	To-DCE	TRANSMIT CLOCK - DTE SOURCE
15	114	DB	To-DTE	TRANSMIT CLOCK - DCE SOURCE
17	115	DD	To-DTE	RECEIVE CLOCK - DCE SOURCE
14	118	SBA	To-DCE	SECONDARY TRANSMIT DATA
16	119	SBB	To-DTE	SECONDARY RECEIVE DATA
19	120	SCA	To-DCE	SECONDARY REQUEST TO SEND
13	121	SCB	To-DTE	SECONDARY CLEAR TO SEND
12	122/112	SCF/CI	To-DTE	SECONDARY CARRIER DETECT***
9	–	–	–	RESERVED FOR TESTING
10	–	–	–	RESERVED FOR TESTING
11	–	–	–	UNASSIGNED
18	141	LL	To-DCE	LOCAL LOOPBACK
25	142	TM	To-DTE	TEST MODE

* CG NO LONGER USED

** SEE PIN 12

*** IF SCF NOT USED THEN CI IS ON PIN 12

INTRODUCTION TO DATA COMMUNICATIONS

EE X491 4Units

Instructor - Dr. K. Sherman (714-633-9228)

Schedule of Assignments

Date	Subjects	Chapters
21 September	Introduction & Overview	1
28 September	Baudot/BPS vs Baud/Carriers/Media	[illegible]
5 October	Circuits/Codes/Interfaces	[illegible]
12 October	Synchronous/Asynchronous/Protocols	[illegible]
19 October	Protocols(cont)/Transmission Integrity	[illegible]
26 October	**MIDTERM EXAM**	1-9
2 November	Modems/Digital Services	10-11
9 November	Multiplexers/Hardware/PBX/Terminals	12-[illegible]
16 November	Packet Switching/LANs/Satellites	14
23 November	Bandwidth/Impairments/Mgmt & Control	[illegible]
30 November	Transactions/Apps/Formats/Design/Review	[illegible]
7 December	**FINAL EXAM**	1-14 ~~1-2-19~~ 10-19

DATA COMMUNICATIONS

COURSE CONTENTS

OVERVIEW OF A COMMUNICATIONS SYSTEM
Brief evolution of components in a network
How all the pieces fit together
How to cope with the confusion of terminology and definitions

CARRIERS AND THEIR SERVICES
Service providers—local/long distance/resale/VAN/radio/etc
Service types—dial/leased/FX/tie line/WATS/cellular/etc
Interconnection and certification

COMMUNICATIONS MEDIA
Twisted pair/coax/fiber/laser/infrared/microwave/others
Carrier Systems—analog and digital
The telephone channel—voice grade/wideband/3002/data lines
Media choices—in house/carrier world

CIRCUIT TYPES AND AVAILABILITY
Practical definitions—point to point/multipoint/multidrop/multistation
Dial vs dedicated/leased/private/data/cluster controllers
Half and full duplex circuits—descriptions

CODES FOR DATA TRANSMISSION
Baudot/PTTC/ASCII/EBCDIC
Code set incompatibilities
Controls/transmission/formats/interfaces

INTERFACES
Loop Current—from TTY to PC
RS232/422/423/449—when and where to use
What is DTE/DCE and RTS/CTS?
What are the X and V specs?
Who are the EIA/CCITT/ISO/ECMA/IEEE

SYNCHRONOUS AND ASYNCHRONOUS
Terminology—bit sync/byte sync/frame sync/modem sync/start-stop/etc.
What does sync and async mean to the user
Utilization and application tradeoffs
Speed limitations for multidrop circuits

PROTOCOLS
A functional description for easy understanding
Types of protocols — async/sync bisync/SDLC/ARQ/HDX/FDX/etc.
Specific uses — Xon:Xoff for terminals/X modem/X.PC/MNP/BLAST/Hayes for PCs/MAP and TOP for Automation and offices
Protocol Converters — card/local/remote/VAN
PC to mainframe connections — how/where
Standards — 7 level ISO model

DATA TRANSMISSION INTEGRITY
Validation—echoplex/parity/VRC/LRC/BCC/CRC/checksum
Forward error correction—block/convolutional—when to use
Data compression—instead of faster transmission—String/Huffman
Encryption—public key/commercial/dial up
Availability and integration of all functions—where/how/when

MODEMS AND MODULATION
What does a modem really do?—Low and high speed
Speed vs distance—line driver/short haul/standard/wideband
Simple explanation of amplitude/frequency/phase modulation
What is the difference between bps and baud—should you care?
Evaluating transmissions—eye patterns
Related equipments—emulators/simulators/eliminators/null modems/couplers/suppressors/cancelers/acoustic/autobaud
Standards—V specs—the differences and tradeoffs
HDX vs FDX/2 wire vs 4 wire/dial vs leased/212A vs V.22/fallback speeds

THE NEW DIGITAL WORLD/ISDN
Comparison of digital and analog operations—speed/reliability/availability/economics/bypass considerations/codecs
Equipment terminology—DSU/CSU/CPE/NCTE/channels/channel banks
Vendor differences—ATT vs Northern Telecom—should you care?
What is T-1 and what can it do for me?
Overview of ISDN (Integrated Services Digital Network)
How do fiber optics tie in to digital services?
Projected services and economics

MULTIPLEXERS
FDM/TDM/statistical/intelligent/T1-saving network line costs
Typical network configurations—controls/thruput/piggyback/optimization
Sharing options—ports/lines/modems

COMMUNICATIONS FRONT ENDS
Concentrators/message switches/transaction processors/line controllers
IBM 3705/3725 and their clones—a comparison

PBX-CBX — FOR VOICE AND DATA
The four generations of in-house switchboards
Voice/data integration and data over voice?
Tradeoffs between voice and data switching/matrix switches
Integration of Local Area Networks — PBX as a LAN controller
In house telephone wiring for data
Electronic vs Voice Mail

PACKET SWITCHING
A simple description of network operation
Vendors/Telenet/Tymnet/others
Interfaces described simply—X.3/X.25/X.28/X.29/X.75/etc.
Asynchronous and synchronous connections
Compatible end user protocols/speeds/locations
Why X.25 is not the same for everybody
Ways to make your site X.25 compatible

LOCAL AREA NETWORKS — LANS
Configurations—buss/ring/star/mesh/tree
Characteristics—narrowband/wideband/speed/distance/analog/digital
Operation—CSMA:CD/token ring/token buss/logical ring
Typical vendor offerings—Ethernet/IBM/Sytek/others
Bridges and gateways explained—coax and fiber use
IEEE 802 spec

SATELLITE AND CELLULAR RADIO SERVICES
Operational considerations due to common frequency allocations
Reliability and delay considerations—compensation units

NETWORK MANAGEMENT AND CONTROL
The tech control center
Analog vs digital channels
Network access—testpoints/loopbacks/etc
Analog and digital parameters to be measured
What is a DB and why is it used
Conditioning and equalization—C and D type
Error rates and their measurement—BERT/CERT/BLERT/datascope/etc
IEEE 488 standard for test equipment
Backup/alternate procedures for outages

NETWORK CONCERNS
Unauthorized access/callback/encryption
Transaction processing controls and formats
Network architectures—SNA/DNA/DSN/etc.
Standards growth—EIA/ISO/CCITT/IBM/etc

NETWORK DESIGN FOR THE END USER
Centralized vs decentralized operation
11 key non technical questions to define your network capabilities
14 points affecting response time—the network isn't always to blame
When to use consultants—a practical view
Support requirements—documentation/standards/procedures/personnel

ATTENDEE FORUM
Future directions of Data Communications—new products and services
How long do you wait before making a decision?
Participant questions and answers

DATA COMUNICATIONS 9-21-87

KEN SHERMAN - 714-633-9228

DATA COMM - TELE-COMM. - TELEX - TWIX

~~SEE~~ GLOSARY IN BOOK PAGE 407

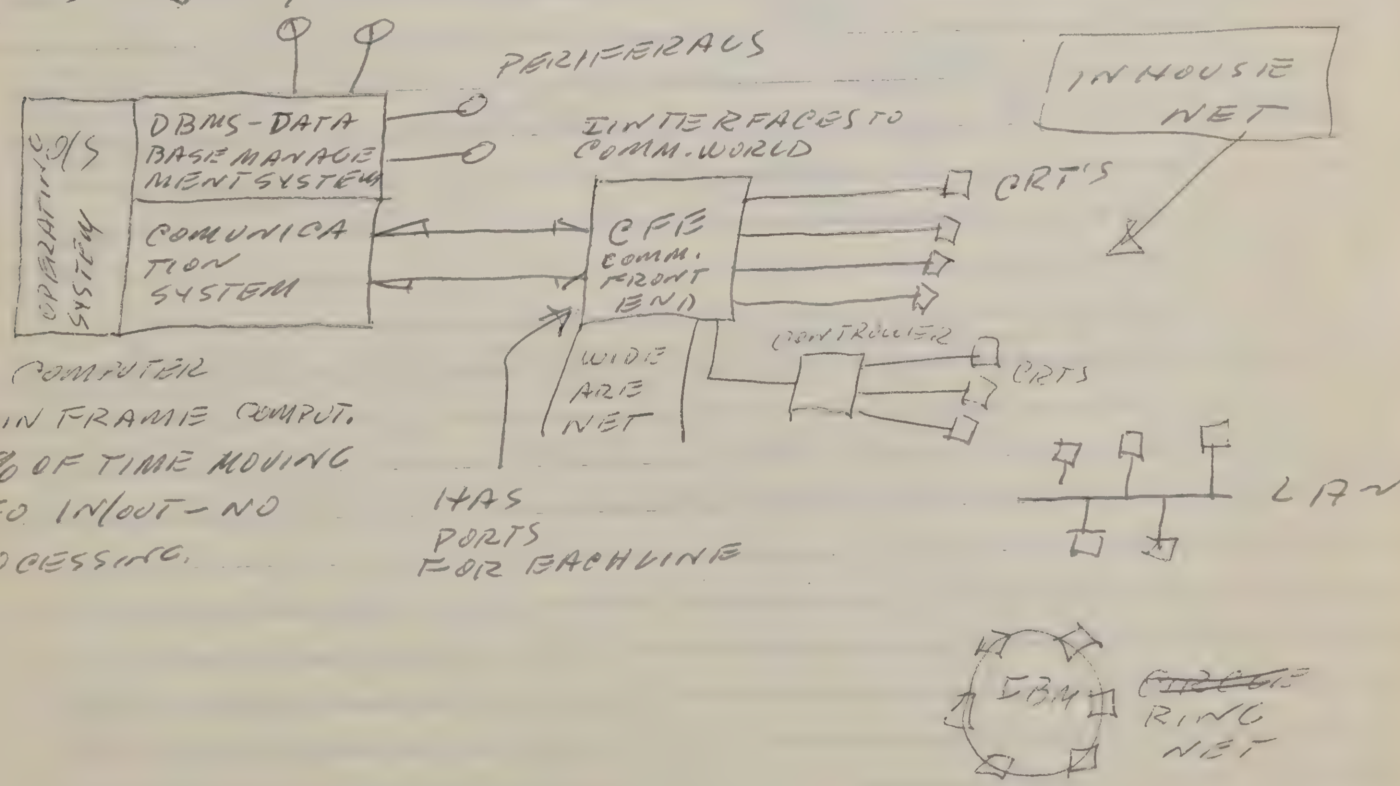
TELE-COM - VOICE DATA-COMM - BINARY DIGITS.

DIGITAL MORE RELAIBLE - LESS NOISE

TRANSMISSION SYSTEM - XMITER, RECEIVER, MEDIUM, CODES

BAUDOT DISTRIBUTOR - SEE PAGE 6

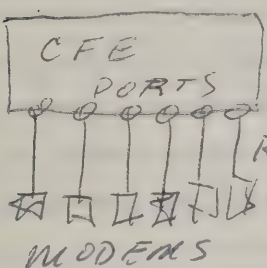
BAUD = BITS/SECOND



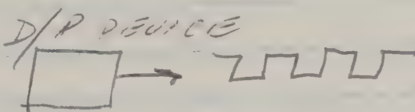
MAIN FRAME COMPUT. 70% OF TIME MOVING INFO IN/OUT - NO PROCESSING.

HAS PORTS FOR EACH LINE

CFE HAS AS MANY PORTS 9-21 CONT.
AS LINES COMING IN -
PORTS - PROTOCOL - RULES FOR DATA COMM. SYSTEMS
SPEEDS - ETC BI/SYNC.

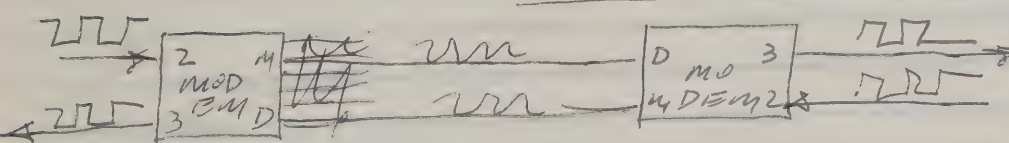


RS = SPEED VS DISTANCE RELATIONSHIP.

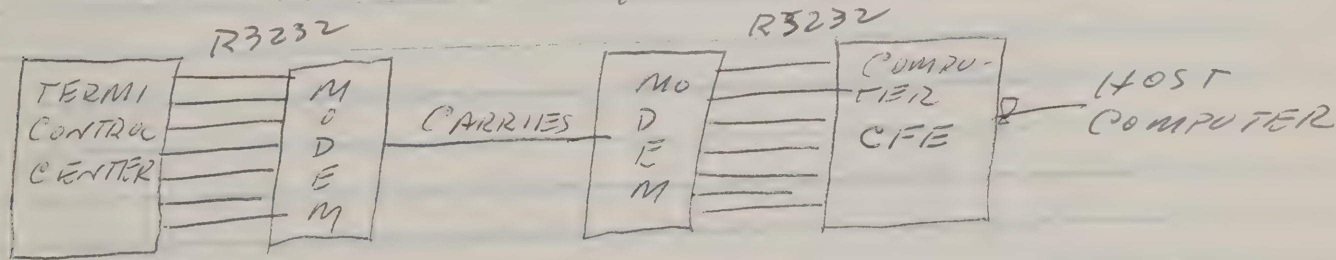


PHONE LINES NOT CAPABLE OF
DIGITAL SIGNALS

VOICE LINES 300 HZ TO 3300 HZ



MODULATOR/DEMODULATOR



POINT TO POINT CIRCUIT LINE

READ CHAP I AND CHAP II -
TRY TO ANSWER QUESTIONS AT END OF CHAPTERS

9-28-87

SE PAGE 4 & 5 OF BOOK FOR DIAGRAMS.
TELEGRAPH - SIMPLEX
HALF-DUPLEX
FULL-DUPLEX

ALL TERMINAL PROTOCOLS = HALF-DUPLEX

ALL CIRCUITS ARE 2 OR 4 WIRE - NO
3 WIRE SYSTEM - TIP & RING-WIRES.

DRY CKT - NO TELE. CO. POWER
TWO WIRE = HALF DUPLEX
4 " = FULL DUPLEX
MODEM - EMULATES VOICE

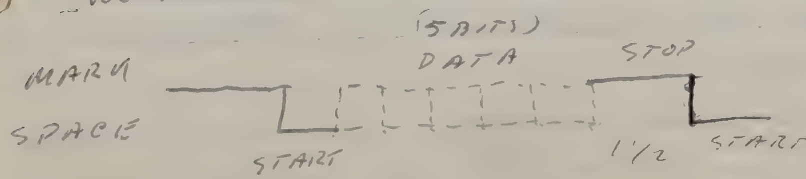
EMIL BAUDOT - CODE - USES 5 WIRES.
CODE = CURRENT IN WIRES DEFINED CODE (PAGES 5 & 6)

BAUDOT DISTRIBUTOR = CURRENT FLOWING IN
LINE = NO DATA
NO CURRENT = BEGINING OF DATA (START)
STOP = CURRENT FLOW 1 1/2 BIT
BAUDOT START OF ASYNCHRONOUS XMISSION -
DEFINITION (CHARACTER FRAMED DATA } ASYNCHRONOUS
" " XMISSION

(START-STOP - MARK - SPACE - MAKE - BREAK
ONE-OFF - 1 - φ = ASYNCHRONOUS.

BAUD BITS PER SECOND $Z = R, C, I$
C & I = CHANGE SIGNAL SHAPE

ROLL OFF =
RS232 = DEFINES MAX DISTANCE = 2500PF MAX.
PHONE TWISTED PAIR 50PF/FT.
MODEMS NEED CLEAN SIGNALS.



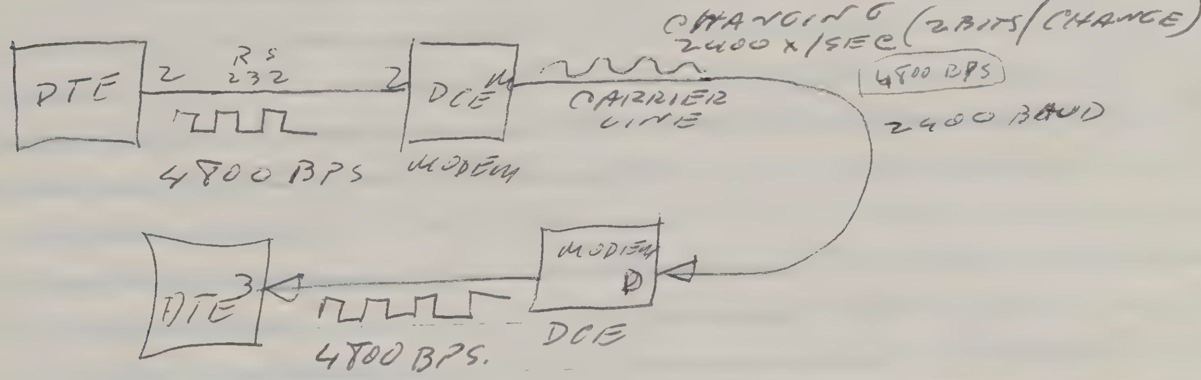
BAUDOT

PAGE 7 - 8

WORST CASE

BAUD = $\frac{1}{\text{SMALLEST INCREMENT OF BIT TIME}}$ = MAXIMUM SIGNAL CHANGE RATE

BAUD RATE & BITS/SECOND → PAGE 8



PAGE 11 DIAGRAM ~ TORN TAPE CENTER

PAGE 10 - MANUAL STORE & FORWARD

→ POLL/CALL

POLL = INV. M → S FOR S TO XMIT (MUST BE ANSWERED)
CALL - INVITATATION FOR A MASTER TO SLAVE
FOR SLAVE TO RECEIVE

DLC PROTOCOLS (DATA LINK CONTROL) } NEED NOT HAVE TO BE ANSWER
HDLC
DDCMP

CHAPT - 2

SEE BYPASS

LOCAL PHONE CO - USER, ⟷ CARRIER
LOCAL LOOP =
LOCAL ACCESS AND TRANSPORT AREA (LATA)
SATELLITE CARRIERS - FOR ~~HI DAT~~ LO DATA RATE - OR VOICE
FOR HI DATA RATE - FIBER OPTICS.

CELLULAR = EACH CELL MINIMUM OF 330 CHANNELS

TYPE OF SERVICE = DDD = (DIRECT DISTANCE DIAL)
PSTN = PUBLIC SWITCHED TELCO NETWORK

- 19000 BPS → LEASE LINES, = DEDICATED, 3002 LINE - PRIVATE LINE
WATS LINE (BANDS)
FEX - OR 800
TIE LINE (FTS - GOVT. NET) 4

DAA

READ CHAPT-3-4-5-6 FOR ~~OCT~~ OCT-5

OCT- 5-

FIG-15-2 PAGE 316 -

AT&T 3002 SPEC FOR VOICE GRADE LINES (PAIR OF WIRES)
- LOCAL LOOP CHARECTERISTICS
HUMAN HEARING 20-20KHZ (K
BAND WIDTH - 0- 4000
- 1/2 POWER LEVEL - 3DB CHANGE
1000 SERIES SPECS 1006 COMMON SPEC.
UPTO 150 BPS.

11 DEGRATION PARAMETERS CHAPT-10

CHAPT - 3 - MEDIA

TWISTED PAIR - LOCAL
COAX - LAN (IN HOUSE) AND X-COUNTRY
FIBER. LOCAL BUSS.- INTRACITY - INTERCITY - LAN'S
MICROWAVE - TERRESTIAL - SATELITE. (LINE OF SITE)
LASERS } IN HOUSE (LINE OF SITE)
INFRORED }
WAVE GUIDE - TO AND FROM MICROWAVE ANTENNAE.
BASE BAND & WIDE BAND COAX
SEE TABLE 3-5 & 3-6 (ANALOG SIGNALS)
3-7 - DIGITAL XMISSION

DIGITAL - NYQUIST THEOREM - ~~THE~~ (SAMPLING RATE MUST BE OVER TWICE HIGHER FREQ OF VOICE
- 8000 PPS - SAMPLING RATE

8000/SEC.

PAM = PULSE AMPLITUDE MOD.
= 64000 BPS - TOLL QUALITY VOICE
8000 PULSES = 8 BITS LONG = 64000 BPS - TOLL QUALITY VOICE
TOLL QUALITY VOICE

PULSE CODE MODULATION 64KBS/SEC
BINARY BITS

T0 = 64 KBPS 24 CHAN. = T1
24 x 64 KBPS = 1.536 MBPS

T1
CHAN. BANK 24 CHAN. AT 8 BITS = <u>FRAME</u>!!
ADD 1 EXTRA "FRAMING" BIT PER FRAME
= 193 BITS/FRAME
8000 FRAMES/SEC x 193 BITS = 1.544 MBPS

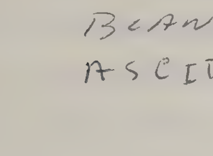
SEE FIG. 3.8 AND ANALYZE

OCT-12- CHAP 5 (CODES)

BAUDOT CODE USED ON TELEX IN U.S.
CODES PAGE (56), 57, 58.
EBCDIC - IBM 8 DATA BITS
BLANK CODES TO BE USED DEFINED)
ASCII OR ANSCII - CONTROL CODES

CHAPT 6 - (INTERFACES)

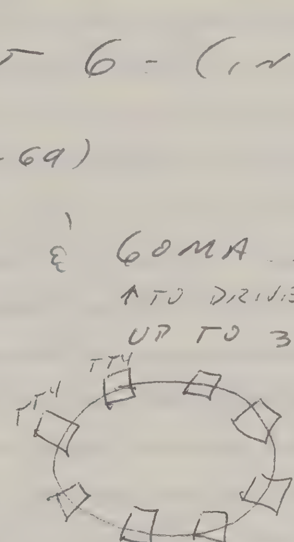
CURRENT LOOP (PAGE 68-69)



LOOP 20MA & 60MA STDS.
↑TO DRIVE LONGER DISTANCES UP TO 30 MILES

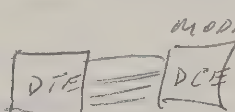
TTY

TELETYPES IN ONE LOOP



ALL HAVE SWITCHES CONTROLLED BY MASTER TTY W/SWITCH

DTE = DATA TERMINAL
DCE = MODEM



2500PF ≈ 50FT
VOLTAGE INTERFACE
RS 232

$P = I^2 R$

MODEM PUTS A CARRIER ON LINE AND DATA MODULATES.

RS232 PAGE-71 (CCITT-INTERNATIONAL-V.21 V.24)

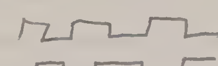
RS232D ELIMINATES PROTECTIVE GND (PIN 1) - WILL BE SHIELD (ONLY ONE GND = PIN)
GND CONFIGURATION POWER GND
SIGNAL GND = DC GND = REF. GND
CHASSIS GND

RS232 PIN 6 AND 20 = POWER ON
PIN 21 = NOT USED ANYMORE.

PIN 23 = BAUD RATE

RS232
(SYNCHRONIZE PINS 3 AND 7)
PINS 14-16-19-13-12 - SECONDARY CHANN.
RS232 = ~~E~~ EIA 232 (SEE PAGES 71 — 77)

LOOP BACK PAGE 347 = TO TEST DIGITAL STREAM
FIG 16-7 a TEST LOCAL S/W
b TEST MODEM
c TEST LINE
d TEST REMOTE MODEM

RS 449 - BALANCED SIGNAL
TWO WIRES
WIRE X
RS422 WIRE Y

DIFF. AMPLIFIER
37 PIN CONNECTOR - NOT USED
REPLACED BY EIA = 530 - HI-SPEED POINT TO POINT

ETHERNET
UNIVERSAL PHYSICAL INTERFACE — UPI NOT USED AT ALL
AUTOMATIC CALL UNIT - FOR MAIN FRAM - RS366 (PAGE 82-83)
DATA ACCESS ARRANGEMENT - 85-86-87 -
DMI & CPI — DESIGN FOR PBX FOR T-1 RATES
~~ISDN~~ PAGE 89 $\boxed{\text{V \& X DESIGNATORS}}$
V SPECS FOR INTERNATIONAL - X SPECS = PACKET
FOUR SPECS TO KNOW - (DIAL NETWORK)
FIG - 6 - 7
LO SPEED X.3 PACKET ASS. DISASS (PAD)
X.28 DEFINES PARAMETERS.
X.29
X.75 PACKET BRIDGE.
CHAPT — 7 PAGE 99

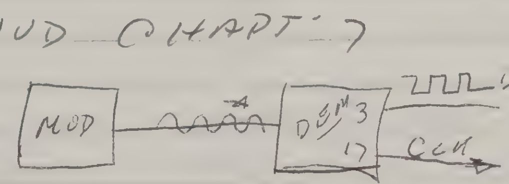
SYNCHRONOUS - ASYNCHROUS.
<u>ASYNCHRONOUS</u>: ALLOWS TO XMIT ONE CHARACTER - ~~...~~
START OR STOP — <u>USES NO CLOCKS</u>
CHARACTER FRAMED DATA
" " XMISSION
IN HOUSE, ANY SPEED - CARRIERWORLD
MAX 1800 BPS. DATA SPEED

SYNCHRONOUS XMISSION PAGE 161
CLOCK SIGNAL IN PIN 17 OF RS232
DATA IN 3 - LOOKS AT DATA IN MIDDLE
OF DATA BIT WHEN IT IS STABLE
MODEM SYNCHRONIZATION TIME
LINE SYNCH TIME
MODEM TRAINING TIME — AT 2400 BPS = 3-5 MS
LINE TRAINING TIME

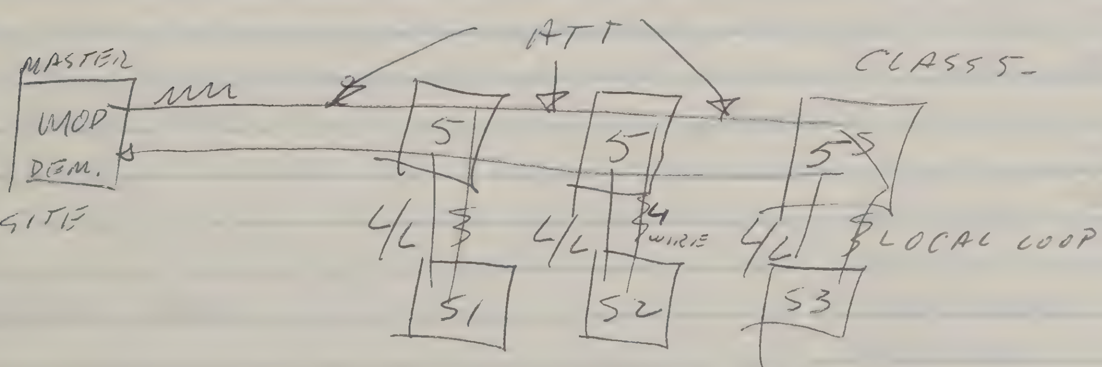
2400 BPS	3-5 MS
4800 "	40-50 MS
9600 "	UP TO 300 MS
14.4 "	5-15 SEC.

CLOCK SYNCH TO DATA

OCT-19- CONTINUD CHAPT 7



DEMO TRAINS ON DATA -
MODEM TRAINING TIME NOT CRITICAL IN POINT TO
POINT - BUT CRITICAL IN MULTIPOINT



MOD PUT'S CARRIER ON LINE TO ALL STATIONS
DEMODULATOR MUST POLL
SWITCH CARRIER OR SWITCH XMISSION (SCREEMIN MODEM)

---

150 CHAR. XMISSION = 1200 BITS

SPEED	SYNC TIME	XMIT TIME	TOTAL TIME
2400 BPS	5 MS	500 MS	505 MS
4800 "	50 MS	250 MS	300 MS
9600 "	250 MS	125 MS	375 MS

OUT = HIGH XMITT SPEED
IN = SLOWER RESPON "

MODEMS: SPLIT STREAM → OUT = SPEED X
→ IN = " Y
FAST TRAIN 9600BPS SYN IN 5

POINT TO POINT SYNCHRONIZATION - NO PROBLEM
SEE FIG 7-4

BISYNC, BIT SYNC, BYTE SYNC.
PROTOCOLS - A-SYNC OR SYNCH-

SPEE VS. COST ADVANTAGES & DISADVANT.

CHAP 8 - PROTOCOLS

HANDSHAKING & LINE DISPLINE
BLUE BOOK PAGE 32
OSI PROTOCOL - 7 LEVEL PROTOCOLS
PROTOCOLS

HDX PROT-	MOVE INFO	2 DIR.	1 WAY AT A TIME	BETWEEN SAME 2 POINTS	TTY BISINC TERMINAL NAME FLOW CONTROL
FDX PROT	"	"	SIMULT.	"	HDLC SDLC ADCCA DDCMP
F/FDX PROT	"	"	"	MULTIDROP M → SX M ← SY	4

FIG - 8-13 PAGE 134

						MODEM
1	HDX	HDX	P.C DIA,	BISINC DIAL	→	2WIRE FDX
2	FDX	HDX	BISYNC	LEASED	→	2 WIRE FDX OR HDX
3	FDX	FDX	SDLC	LEASED	→	4WIRE FDX OR HDX
4	HDX	FDX	SDLC	DIAL	→	4WIRE FDX
5	FDX	F/FDX	SDLC	LEASED	→	2WIRE FDX
					→	4WIRE FDX

ALL P.C. MODEMS MUST BE F DUPLEX

IDENTIFIED CKT USES BEFORE SELECTIN MODEMS.
DRAW BOXES IN PICTURES SHOWING MODEMS. ETC.
IN DIAGRAM

CKTS - PROTOCOLS - MODEMS - ECHOPLEX

ECHOPLEX

~~ECHOPLEX~~ - SWITCH HDX TO FDX.

FDX - ECHO CHARACTER AFTER BEING RECEIVED BY REMOTE COMP. AND DISPLAYED

HALF DUPLEX. KEYED, DISPLAY & XMIT

FDX KEY - XMIT - SEND BACK AND DISPLAY

READ BISYNCH PAGE 112 } NOT IN EXAM
" SDLC IBM - PAGE 115 }
" WALK THRU ONE TRANSMISSION }

FIG. 8-5 BYTESYNCH
" 8.8 BISYNC - TELEMETRY - COUNTS BYTES

PROTOCOLS PAGE 45 (BLUE BOOK)

XON XOFF
DTR ON AND OFF PRINTER CONTROL
ETX/ACK - PRINTER
FLOW PROTOCOLS

P.C. PROTOCOLS (PAGE 47)

PAGE 129 - 130, 131, 132

USE GRAPH PAPER FOR TIMING DIAGRAM

PAGE 136-137 AND PAGE 49 IN BLU BOOK

NOV - 2 -
POST- MIDTERM TEST (ADD 7 POINTS TO SCORE)

CHAPT- 9.
~~PAGE 147~~

ERROR DATA-
FOWARD ERROR CORRECTION FEC.
ERROR CORRECTION ADD RECEIVING END
PARITY PAGE 147

ODD PARITY - EVEN PARITY
VERTICAL CHECKING
UNDETECTED ERROR - TWO BITS CHANGE (0-1) TO (1-0)
PARITY
USED INTERNAL TO CPU - NOT USED ANYMORE

LONGITUDINAL & VERTICAL

BLOCK CHECK CHARACTER - ADDS ALL BITS AND TAKE THE LEAST 16 BITS

CHECKSUM (BCC) ADD BINARILY 8 BYTES

BCC																

REMEMBER THIS INFO

OTHER MECHANISM - CRC PAGE 151
CYCLIC REDUNDANCY CHECK
FIG - 9-3 - (CRC - TAKING ANY BIT STREAM AND DIVIDE BY A PRIME NUM.)

MAX NEG LENGTH
$= 2^N - 1$: N = # OF BITS REMAINDER
8 BITS $= 2^N - 1 = 255$ BITS MAX MESS LENGTH
16 BITS $= 2^N - 1 = 65{,}535$ BITS
CRC = MOST POWERFULL ERROR DETECTING SYSTEM

$\boxed{1.11\text{--}12\ \phi\text{--}101}$ IBM DETECTION
17 BITS

BCH - CODE -

HAMMING CODE - CORRECTS 1 BIT ERROR

FORWARD ERROR CORRECTION — FEC !!!
BLOCK & CONVOLUTIONAL PAGE 158

1/ REAL TIME
2/ CORRECT UP TO 50% OF ALL BITS XMITED IF THEY ARE IN ERROR
3/ CAN BE MADE ON THE FLY
4/ ~~USED IN~~ PRACTICAL FOR LONG PROPAGATION DELAY AND HIGH SPEED (SATELLITES)

DISADVANTAGE: MUST ADD MORE BITS TO MESSAGE

DATA COMPRESSION - 159 -

(1) STRING CODING: PUTS INTO STRING OF BITS
VIDEO XMISSION - PIXELS - 90 MBPS (COMMERCIAL)
USED IN FAXIMILE

(2) FOR BINARY STREAM TYPE - FACSIMILE ETC. - VIDEO

(3) HOFFMAN CODING:
50% COMPRESSION BASED ON ASYNC ASCII
20 TO 50% REDUCTION WITH ASCII - NO PARITY AND NO START & STOP BITS - USE FEC

(HOFFMAN TREE PAGE 161)

ENCRYPTION PAGE 165 FIG - 9-7

CLEAR TEXT - $\underset{\text{ADDS ALGORITHM}}{\overset{\text{RED}}{\text{CRYPTO}}}$ - $\overset{\text{BCH}}{\text{CIPHERTEXT}}$ - $\underset{\text{REMOVES ALGORITHM}}{\overset{\text{RED}}{\text{CRYPTO}}}$ - CLEARTXT

ENCRYPTING CODE
56 BITS DES - APP BY NBS AND CONTROLLED BY N.S.A

FIG - 9-8 PAGE 166 - WORK IN BIT STREAM - STRAPING ACTION

MODEMS:

PAGE 174 - FIG 10-1

DTE RS232 DTE 50F / 20KBPS
LINEDRIVER 2000F / 19.2 KBTPS
SHM - LIMITED DISTANCE MODEM 10MILES / 19.2 KBPS
SHM / LDM
SHORT ~~HUL~~ HAUL MODEM

SAME DEFINITION
- METALIC WIRECKTS
- UNLOADED "
- NON LOADED "

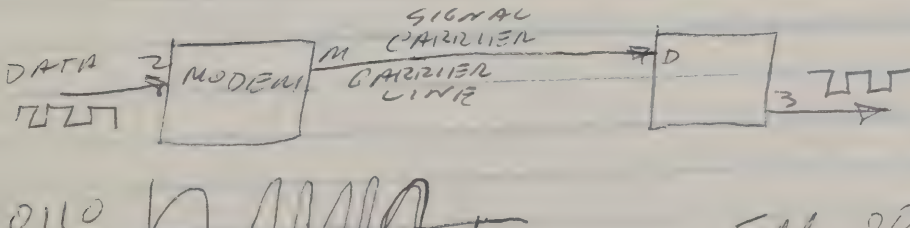
M.D.M — 40MILES / 19.2 KBPS.

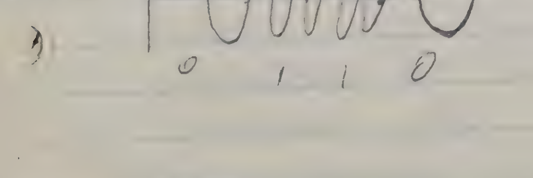
STANDARD MODEM - ANYWHERE CARRIERS GO AT 19.2 KBPS.

PAGE 177 - FIG. 10-2

RETURN TO ZERO - SELF CLOCKING (INTERNAL) CPU
NON-RETURN TO ZER - MAGNETIC MEDIA - (TAPE)
BY-PHASE MANCHESTER SELF CLOCKING - ETHERNET
BIPOLAR SIGNAL PULSES - ELIMINATES BIAS.

~~BY CONVENTION~~ PAG. 179 MODEMS
MODULATION:
FM - FREQ. MODULATION
FSK - FREQ. SHIFT KEYING (2 CARRIER SIGNALS)
CARRIES #1 = 0 BITS = 1200 HZ.
CARRIER #2 = 1 BITS = 2400 "

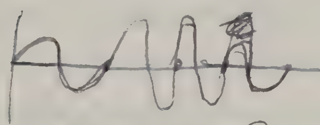




FM OR FSK

MODEMS

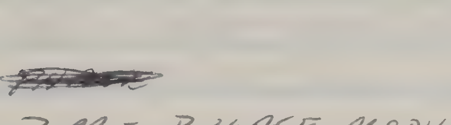
A.M.
ONE CARRIER ≅ 1800 HZ.

0110 
0 1 1 0

NEVER USED BY ITSELF -
MOST NOISE SENSITIVE

~~PHASE~~
PM - PHASE MODULATION (PSK - PHASE SHIFT KEYING)

~~NO Φ CHANGE~~ ONE CARRIER
1800 HZ.

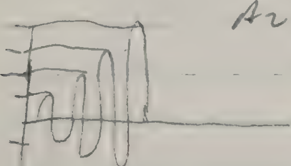
0110 
0 1 1 0

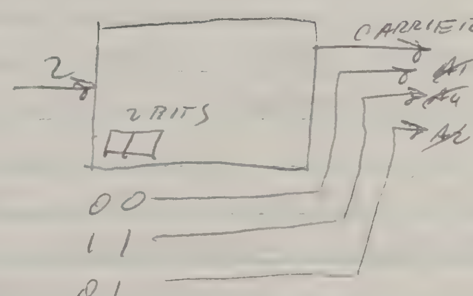
ALWAYS USED IN SYNCHRONOUS
XMISSION -

NO Φ CHANGE = 0 BIT .... IN FDX MODEM 212
1/2 CYCLE Φ CHANGE = 1 BIT .... 1200 BPS USES PSK.

1 CHANGE OF SIGNAL = 1 DATA BIT = 1/BAUD

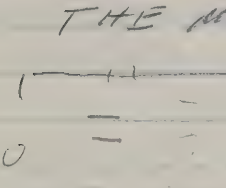
IF AM = A_1 = 00 A_3 = 10
A_2 = 01 A_4 = 11





2 BITS/
BAUD

3002 ALLOWED MAX SIGNAL AMPLITUDE LIMITS
THE MAX AMOUNT OF AMPLITUDES = 0 DBM = 1 MW.



AMPLITUDES LIMITATION (DATA CAPACITIVE)
IS NOISE IN LINE

PAGE 21 - IN BLUE BOOK
PAGE 185 -
COMBINATIONS OF PHASE AND AMPLITUDE

NOV - 9 -

DATA SERVICE UNIT (DSU)
SPLIT CHANNEL.

1070 1270 2115 2315
Ø 1 Ø 1 FSK

PAGE 186

103 MODEM
212 STANDARD PSK. MODEM SIM. TWO WAY
XMISSION - INT. V.22

212 600 MOD 4 PHAS. 4 BIT/PHASE

4 X 600 = 2400 BPS PER CHAN.

TWO INDEPEDENT

FIG - 10-8 - TWO WIRE CKTS

FIG - 10-9 - 212 MODEM

— MODEM —

ORIGINATE ONLY + ANSWER ONLY
ORIGINATE/ANSWER MODEM
DESIGNATES WHICH PART OF BAND.
ORIGINATE - LOW END OF BAND

FREQ. FOR 212 MODEM → TTY TYPE
MUST USE WITH P.C. BECAUSE IS A CURRENT
PROTOCOL - LINE TURN AROUND

OPERATE SAME AT
V.22 VS 212A - 1200 BPS — 600 BAUD - 4 PHASES
PSK - 2 BITS PER PHASE
PAGE 21 OF BLUE BOOK -

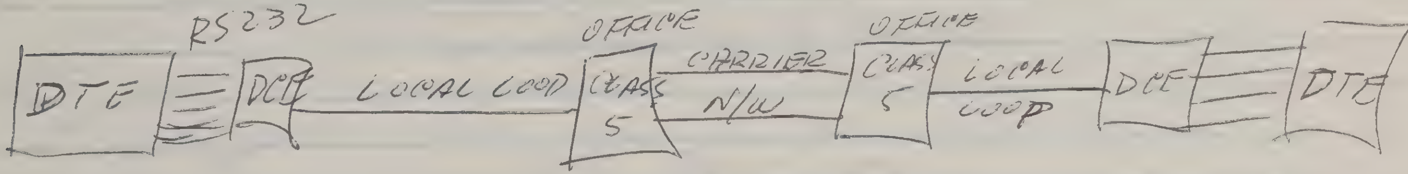
212 BACK UP MODE 300 BPS P. T. AND T. (POSTAL & TELEPH. AND TELEGR.
V.22 - 600 BPS.

V.22 BIS MODEM

V22 BIS STANDARD FOR INTERN. & N. AMERICA.

V32 USES TRELLIS CODED MODEM AT 9600 BPS.
SUBJECT TO LINE PROBLEMS

MISSMATCHED IMPEDANCES.
ECHO CANCELLATION (ECHO SUPPRESSION) PAGE 198



IN MODEM → DIGITIZE OWN XMISSION
← DIGITIZEZ COMBINED SIGNAL
→
← DIGITIZE LOCAL ECHO
← DIGITIZE REMOTE ECHO
GENERATE A SIGNAL TO CANCEL ECHO ON BOTH

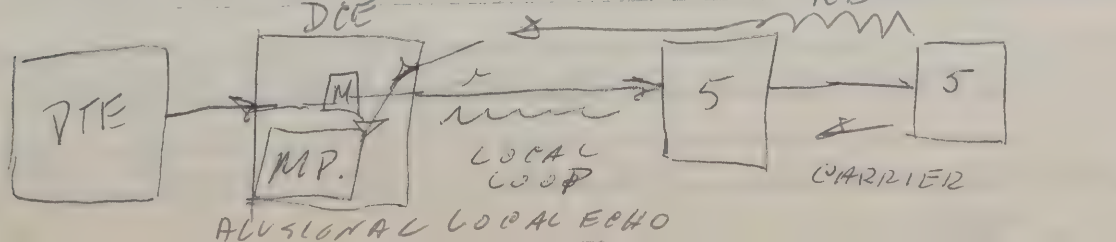
ALL SYNCHRONOUS XMISSIONS.

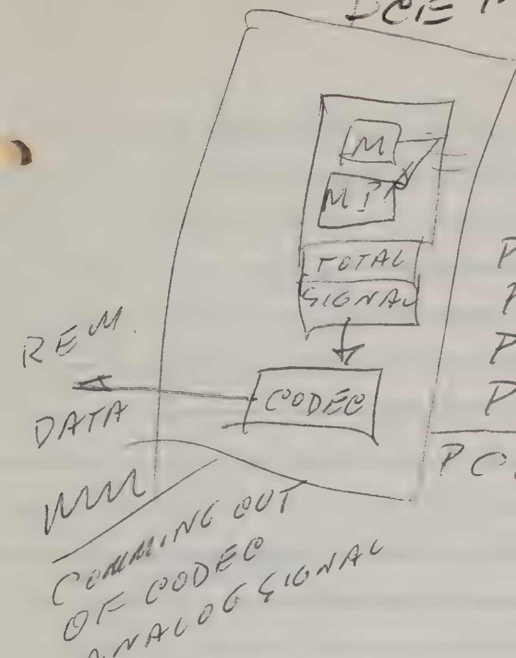
SEE PAGE 17 BLUE BOOK
REPLACES TABLES ON PAGES 190-191
DPSK - DI-PHASE KEYING - MORE THAN BAUD
BAUD & RATE NOT SAME
QAM - UTILIZES 2 CARRIER SIGNALS AT SAME ~~FREQ~~.
SINE & COSINE - MODULATES AMPLIT.
TCM - TRELLIS CODE MOD. " PHASE

SEE PAGE 20 BLU BOOK - FOR SIDEBANDS
SEE PAGE 22 SPREAD SPECTRUM

SPREAD SPECTRUM) SHORT DISTANCES, RADIO
1 BIT = 100011 } WAY TO SCRAMBLE
0 BIT = 011100 } INFORMATION

INFRARED -





USED ONLY WHEN NO DIGITAL SYSTEM AVAILABLE

PCM TOTAL SIGNAL
PCM LOCAL GEN. SIGN
PCM LOCAL ECHO
PCM REM ECHO

PCM OR REMOTE CARRIER

SEE PAGE 192.

AMPLI- PULSE MODULATION 8BITS/SAMPLE

ACUSTIC COUPLER- PORTABLE TERMINALS. EMULATES 103/113

AUTOBAUD - CHANGES SPEED - TWO KINDS-
300 - 1200 BPS
ERRORS TOO HIGH - CHANGE SPEEDS (HIGH RATE OF SPEED)

C TYPE CONDITIONING - BUILT IN
D TYPE - NOT BUILT

ECHO SUPPRESOR - LINE UNIDERECTIONAL.
HIBRID CONVERTS 2 TO 4 WIRE CKTS- EACH PAIR HAS ECHO SUPPRESSION - UNIDÉRECTIONAL.
ALL DIAL-UP USE HYBRID
V.32 MODEM HAS ECHO CANCELLERS.

BRIDGE - MONITORS LINE WITHOUT BREAKING LINE,
SEE FIG-10-15 -

MODEM OUTPUT ODB

RJ11C = CUTS SIGNAL - ATTENUATOR

SPLIT CHAN / SPLIT-STREAM DTE MUST BE ABLE TO HANDLE

CHAN-11 - DIGITAL XMISSION
REPLACE MODEM WITH DSU
CSU

CSU - CHANN. SERVICE UNIT
1/ LINE TERMINATION .... NOTE
2/ Z MATCHING
3/ LOOP BACK CAPABILITIES
4/ DIAGNOSTICS

DSU - DIGITAL DATA SERVICE UNIT - 15 PIN CABLE
COMBINED WITH CSU

REGENERATION SWITCH 6000 FT
T1 - 24 CHANN.
DIGITAL ERROR 6 SEC /1000 SEC. MAX POSSIBLE.
AT&T GAREENTEE 99.4% ~~BB~~ BETTER THAN
~~6~~ SEC/1000 SEC.
AT&T CLOCK.

BY-POLAR PULSES GUIDELINES
NO MORE THAN 15 CONSECUTIVES Ø'S
MIN 3 Ø'S EVERY 24 BITS.
PAGE 217

DIAL DIGITAL: TABLE 11-1

DIAL DIGITAL COMMON INTERFACE BETWEEN AT&T AND
NORTHEN TELECOM

TIME COMPRESSION MUXING TCM
"PING PON"
N TEL - 160 KBPS = 2 CHAN - @ 64 KBPS
2 CHAN AT 16 KBPS
AT&T - 144 KBPS = 2 CHAN - AT 64 KBPS
1 CHAN AT 16 KBPS

ALL DIGITAL XMISSION ECHO CANCELLATION
MAX DATA RAT 64 KBPS

SEE BLUE BOOK PAGE 1 ⟶ AND ON

PAGE 6 - BLUE BOOK.
READ ABOUT T1 - PAGES 7-8-9-
PAGE 10 - FRAMES

SS7 - BETWEEN CARRIERS ONLY SIGNALING

Q 921 } USER TO CARRIER SIGNALING
Q 931 }

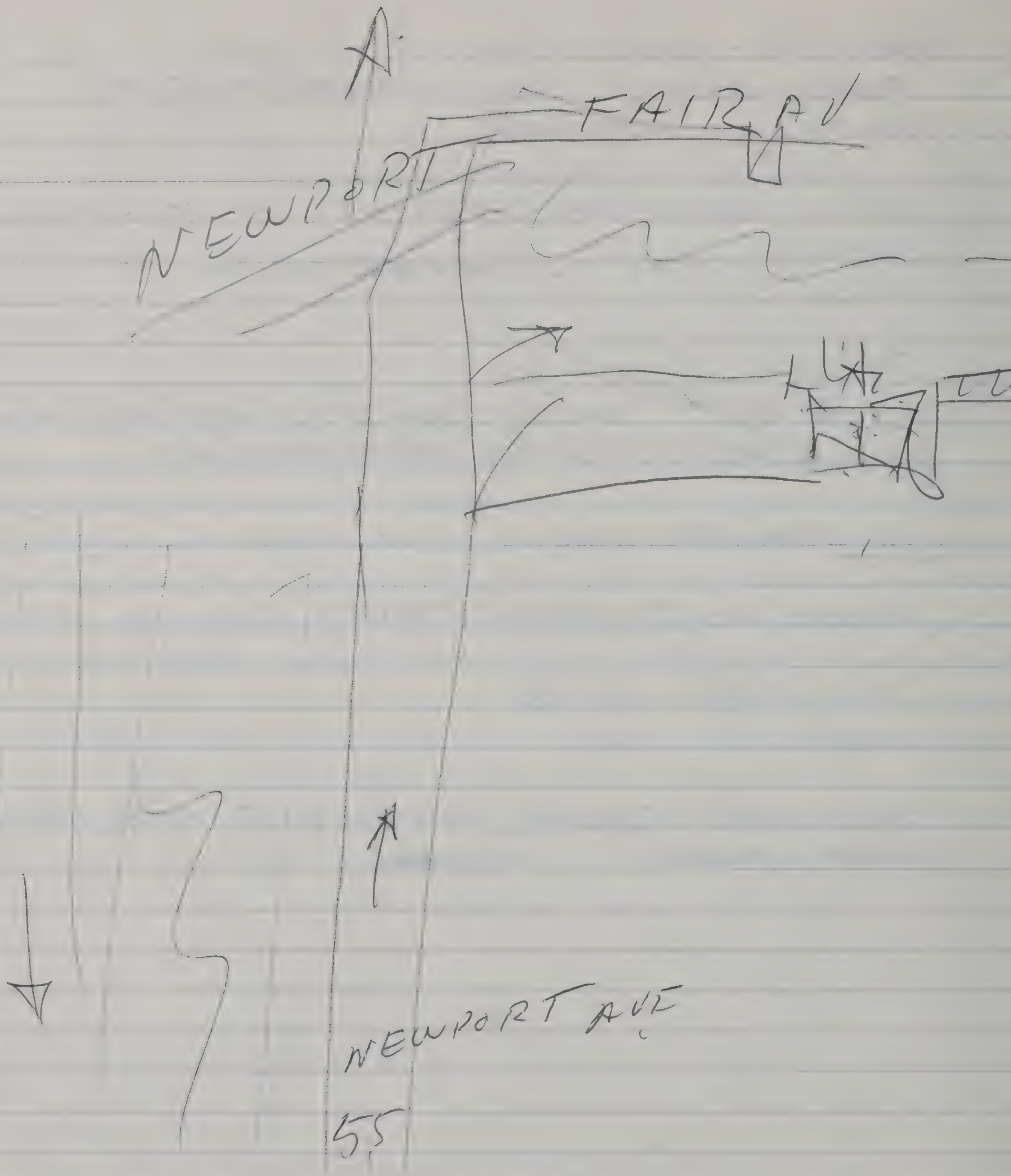
PROJECT VICTORIA
1 B + D → 1 DATA AT 9600 BPS, 4 DATA AT 1200 BPS
64 KBPS = 2 - 32 KBPS VOICE CHANNELS

H CHANNELS FOR

PAGE 218 - 219 TEXT -

DIGITIZED VOICE
PAGE 220 - 221

CELLULAR RADIO - 224 - 225 FOR VOICE
BYPASS MODES ___ FIBER



FAIR AV
NEWPORT
NEWPORT AVE
55

NOV-16- CHAPT- 11

PAGE 231 MULTIPLEXER SAVE LINE COSTS
FIG- 12-1

SITE A = SEATLE
" B - SFRISCO

5 LINES A $1400/MONTH =
$7000 MONTH
SPR MODEMS

MUX
1 LINE AT $1400/MONTH = $1400/MONT
4 " AT 500/MONT = $2000/MONT
2 MUX AT 500/MONTH = $1000/MONT
5 PRS MODEMS $4400

STANDARD MUX
TOTAT BIT CARRYING CAPACITY
OF LO SPD LINES ≤ BCC HI-SPD LINES
9600 BPS MAXI

FDM = F
TDM =
FIG-12-4 PAGE 232

STAT MUX/INTELLIGENT MUX (PAGE 236)
(STATISTICAL)

(BIT CARRYING CAPACITY)
RULE OF THUMP - TOTAL B.C.C LO SPD LINES ≤ 4 X B.C.C
HI-SPD LINES.

PAGE 238 - 239
" 240 - 241 - EFFICIENCY OF XMISSION
~~#4~~ THAT MAKES SENSE = #4 TRUE EFF.

T1- MUX - PAGE 242 - LO - SPD. LINES
FIG- 12-7 64KBPS. CHAN.

$\boxed{\text{5 LOCAL LOOPS = 1 T-1 CAT.}}$

CHAPT- 13-

CONCENTRATOR- TO REDUCE # OF PORTS. FIG- 13-1.
ALSO TO BY-PASS CFE. (SPEED PROBLEM)

MESSAGE SWITCH — ROUTING + CONCENTRATOR.

ELECTRONIC MAIL- NON-REAL TIME DELIVERY
STORE DATE FOR LATER XMISSION

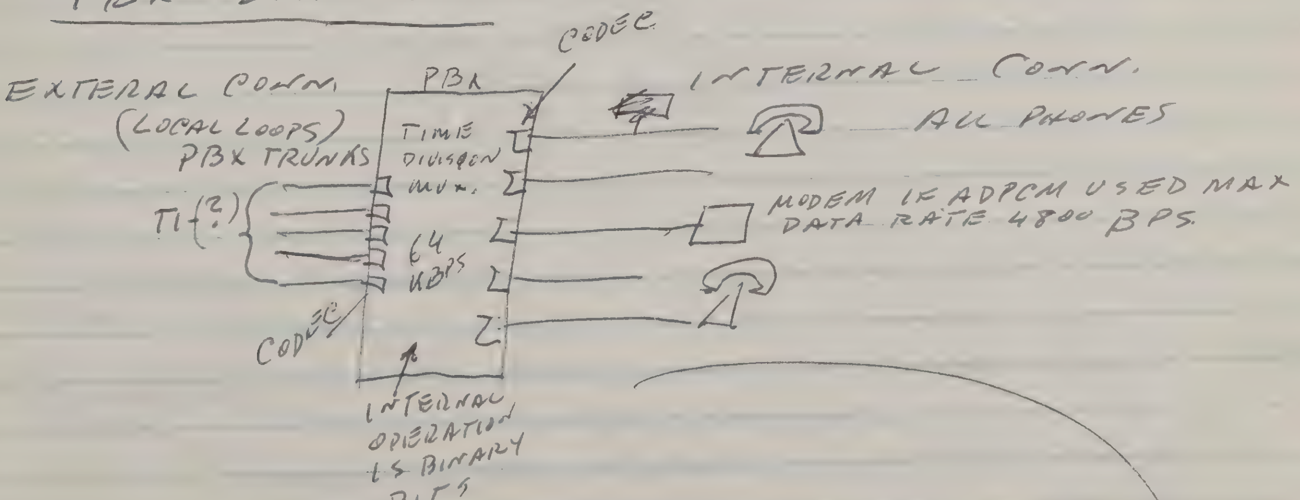
PAGE 253-54-55- = CFE
MOST POPULAR IBM 3705/3725 FRONT END)
CFE = HOST SIDE DTE- EVERY PORT IS A DTE PORT.

THIRD GEN. SWITCH

PBX & CBX -
PRIVATE BRANCH XCH

CBX- VOICE DIGITEZ PAM (PULSE AMPL MOD).
CBX2- DIGITAL - BINARY BITS
BLOCKING & NOT BLOCKING - BLOCKING: NOT ENOUGH LINES IN TRUNK FOR ALL PHONES-
ALL PBX ~ 1983 NON-BLOCKING

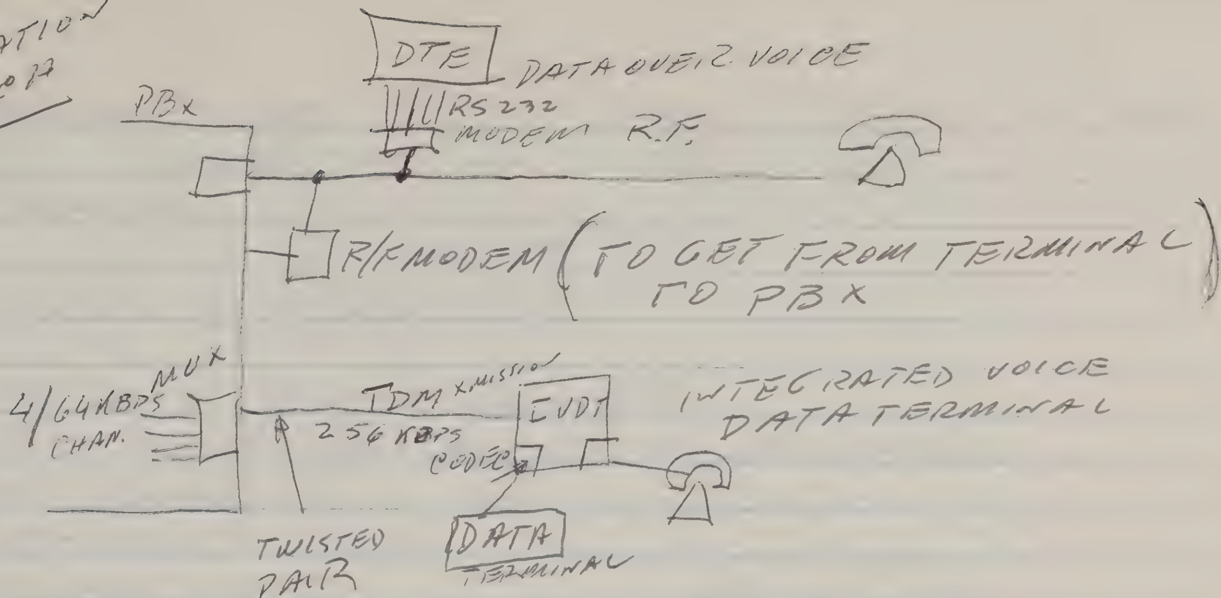
PBX DIAGRAM



ADPCM. ADAPTIVE D---- PULSE CODE MODULATION
TOLL QUALITY VOICE
64 KBPS = DATA SAMPLING RATE

SEE NEXT PAGE

THIRD GENERATION SWITCH

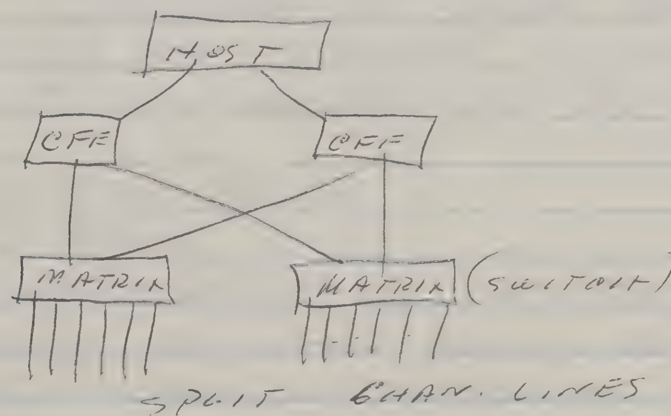


MAX DATARATE FOR IVDT 56 KBPS

DATA PBX

IVDT $1000-$1800 PER LINE
PBX (NO DATA) $500/LINE

MATRIX SWITCH — NOT A DATA PBX



FOURTH GENERATION SWITCH - NOT GOING ANYWHERE

CENTREX = PBX RESIDING IN LOCAL CLASS 5 TELE-COM CO. - ENHANCED SERVICE -
CENTREX = ~~LESS EXPENSIVE~~ - NO MAINT. - PHONE CO RESPONSIBILITY
OPEN 24 HRS/DAY - COMPATIBLE WIT X.25 - CENTREX
MORE EXPENSIVE - COST/LINE - POTENTIALLY FLEXIBILITY INTEGRATION WITH NEW SERVICES,
TIP & RING

TERMINAL TYPES. (PAGE 266) (READ) (NO TEST)
" SELECTION → ~~271~~ - 272
COST ANALYSIS

CHAPT 14

PACKET SWITCHING:

UNINET AND TELENET MERGED.
PACKET INTERNAL CONFIGURATION IS SAME.
DEFINE PACKET
BIT MOVING FUNCTION
SEE FIG 14-1 VIRTUAL CKT
ENTRANCE NODE SENDS PACKETS IN DIFFERENT
DIRECTIONS TO REMOTE EXIT NODE.
1. WHERE ARE NODES (NEED TO KNOW) (TELENET HAS 700 NODES)
2 PROTOCOLS. LOCATION OF NODES (COST)
3- SPEEDS - ALL NODES SUPPORT 1200 BPS, SOME 6400.

TWO WAYS OF COMMUNICATIONS WITH PACKET
1 = X.25 - SYNCHRONOUS - 2400, 4800, 9600, 56000 BPS.
AT RECEIVING END TERMINAL INTERFACE
IS A X.28 THA COMMUNICATES WITH A X.3 PAD

TWO REASON TO USE PACKED
1- POINT TO POINT
2- COST VS UTILIZATION - FIG-14.3
DUPPOSE TO TIE MANY TERMINAL TOGETHER
X.25 INTERFACE CAN SUPPORT 1024 TERMINALS (56KBPS)
SEE PAG 289 FO X.25 USSAGE

DON'T READ 283 TO 288 OBSOLETE (NO TEST)

NOV-23- CHAPT-11-

FOR TEST:

SELF ADDRES ENVELOPED W/ 34 CENT STAMP.

PAGE 293 - LAN !!

2 MAJOR DIFF.

PUBLIC LANS - PROVIDE A MEDIUM TO MOVE BITS

P.C. LANS - NEEDS A ~~RE~~ CKT IN P.C.

PUBLIC ETHERNET.

USES CARD TO ADDRESS PERIFERALS. BYPASSES OPERATING SYSTEM - TOO SLOW - P.C. LANS MUCH FASTER.

TWO OR THREE SERVERS NETWORK

ALL PC-LANS = NARROW BANDS

NARROW BAND	WIDE BAND
BASE BAND	BROAD BAND
ETHERNET	WANGNET
STARLAN	SYTET
10MBPS. ETHERNE	460MBPS
1MBPS STARLAN	
1/2 MILE	5-10 MILES
1 USER AT TIME	MULTIPLE USER SIMULTANEOUSLY IN DIFFERENT BANDS
GOOD ONLY FOR SHORT BURST TRAFFIC (DATA)	DATA/IMAGE GRAPHICS ~~FAX~~.
CSMA/CD SEE BOOK. TOKENS	TOKENS POLL & CALL ANY CHAN. CAN OPERATE AS A NORROBAND.
SHORT DISTANCE IN HOUSE OFFICE TYPE	CAMPUS NETWORKS - BACKBONE ALSO OFFICE FUNCTIONS.

NORROW BND	WIDE BND
COST = X	COST = 1.3 X

PAGE 293 FIG- 14-4

BUS NET = ETHERNET, STARLAN (P.C. LANS)
RING NET: MAU = MULTISTATION ACCESS UNIT
STAR : PBX AS CENTRAL POINT (PC. AMDU. ETC)
TREE NETW: WIDE BAND MULTIPOINT
MESH NET A: NOT USED (FULLY CONNECTED
MESH NET B: BRIDGE CONNECT 2 SAME TYPE OF LANS

GATEWAYS: CONNECTS 2 DIFFERENT TYPE OF LANS — (PROTOCOL CONVERSIONS) (ROUTERS)

BUZZ WORD: INTERCONNECTIVITY FOR MULTIPLE NETWORKS.

PAGE 294

a I/F = INTERFACE -
FOR XMITT = TURN ON REQUEST TO SEND (SIGNAL BY PHASE MANCHESTER - SELF CLOCKING MECHANISM.) ~~CHESTER)~~
CSMA/CD = COLLISSION DETECTION WHEN TO XMISSION GO AT SAME TIME.
ETHERNET - INTEROFFICE DATA - (XEROX)
LOGICAL RING = TOKEN PASSING RING - CAN'T XMITT UNLESS YOU HAVE A TOKEN -
DISADVANGE OF LOGICAL - SLOW FOR COLLISSION DETECTION
COLLISSION AVOIDANCE - SENDS MESSAGE REQUESTING BUS

b - TOKEN RING: (IBM) TOKEN - 3 BYTE TOKEN
10 MBPS

| A | B | C |

A & C DELIMITERS
B - DATA BYTE

ADDRESS OF RECEIVING STATION IS PART OF HEADER,

DATA BITS ---- | MSG. | DELIMETER |
BUSY

TOKEN IS SENT BY GENERATING MESS. STATION.

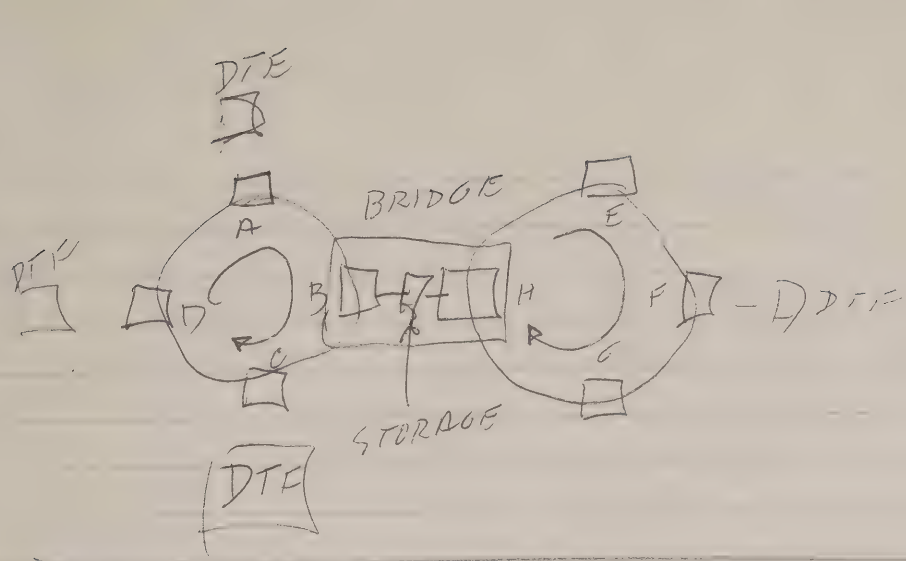


FIG - C - TOKEN BUS

WIDE BAND - NO. P-C. MASTER CONTROLLER - CONVERTS INCOM. FREQ. & CONVERTS TO OUTGOIN FREQ. = ALL ANALOG.

I/F = RF MODEMS.

INDIVIDUAL BANDS WITHIN THE WIDE BAND AREA.

EACH CHANNEL = DIFFERENT FREQUENCIES

10 MBPS IN ONE CHAN.

9600 BPS IN ANOTHER CHAN.

FIG 14-5 DATE

ATT = ISN (INFORMATION SERVICE NET.) = LOCAL TEL. CO - DATA KIT

BANK AMERICA = VIRTUAL CKT SWITCH - NOT PHYSICAL CONNECTION

I/F CONNECTED TO END USER = TTY, BISYNC, SDLC, HDLC - (UP TO 1024)

IF A → C - GOES TO SWITCH AND TO C

DATA IN PACKET FORM - ASSEMBLED AND DISAMBLED IN I.F. 56KBPS MAX DATA RATE -

DATA KIT IS PHONE OFFICE

TIME DIVISION MULTIPLEXING -

SEE SPECIFICATIONS ON PAGE 299 - IEEE SPECS

802.3 .4 .5 ~~PIECE OF~~ 1ST AND PIECE OF SECOND LAYER OF PROTOCALS

PAGE 300 COMES OUT NO READ

PAG 303 SATELLITES - MICROWAVE LINK

PROPAGATION DELAY - 1 TO 2 SECONDS
SOME TIME BLACK OUT WHEN SAT, SUN AND DISH ALINE

- LONG DISTANCE COMM.

TELETX - VIDEOTEXT - ~~TAKES 15~~ 15 MINUTES/SCREEN
PRODIGY - IBM & SEARS FOR MAKETING AND ORDER

CHAP 15 & 16 -

PAGE 315
DB = MEASURE OF POWER
DB - CONVINIENT TERM
3002 - VOICE GRADE LINE SPEC.
POWER - ABSOLUTE & RELATIVE TYPES
MODEM OUTPUT 0 ± 4 DB
MIN FROM TELCO = -16 ± 4 DB
LOGARYTHMIC.
EVERY +3DB = DOUBLE PREVIOUS VALUE
" -3DB = HALFS " "

LOG OF A # > 1 = POSITIVE VALUE
" " " 0 < # < 1 = NEGAT. " (FRACTION)
" " 1 = 0

0DB = 1 MILIWATT

0DB = 1MW
-3DB = .5MW
-6DB = .25 "
-9DB = .125 "
-12DB = .0625
-15DB = .03125
-18DB = .015625
-21DB = .0078125

ABSOLUTE = SIGNAL LEVEL
RELATIVE = RATIO
XMITT/REC = LEVELS
SIGNAL/NOISE

TELEFONE REF TEST TONE
1MW AT 1004 HZ AT 600 OHMS

NOT IN EXAM

PAGE 326 - 327

CONDITIONING & EQUILIZATION

"C" TYPE IMPROVES = ATENUATION AND ENVELOPE
" WHAT THE LINE DOES - Z MATCHING
ETC.

"D" TYPE - ONLY ON LEASE LINE - SIGN/NOISE &
HARMONIC DISTORTION

CHAPT - 16

FOR TEST BRING
PAPER CLIP -
ENVELOPE W/44 CENT STAMP

NOT TOO MUCH TIME
ON THIS CHAPT

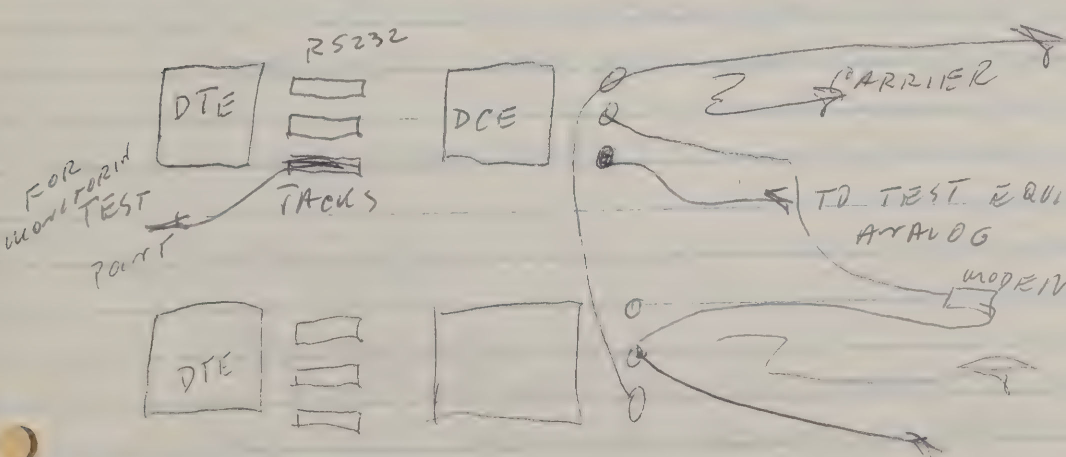
CONCEPT SECOND HALF OF BOOK -

PAGE 331 - LIST OF 8 ITEMS.

#4 - >50% LINE UTILIZATION CAUSES PROBLEMS
#5 - CAN'T CHECK IF SOMEONE ELSE IS LISTENING
#8 - IDENTIFY ALL USERS. P.C., - KEEP RECORDS.

PAGE 332 LIST OF 4 ITEMS

ACCESS INTERFACE DEVICE



PATCH-PANEL

PAGE 337 - FIG - 16-4
" 16-5 CONFIGURATION OF MOST
COMPUTER USES TODAY FOR TEST.
REVERSED AND SPLITCHANNEL USE THIS METHOD.

PAGE 338 - FIG - 16-6 - TOTAL AUTOMATED SYSTEM
END TO END TEST ONLY

PAGE 339 - IEEE - 488
" 340 - ANALOG PARAMETERS (NO TEST)
342, 343 - MORE OF SAME.
344 - DIGITAL - 345 - TEST EQUIP. FOR DIGITAL
MUST HAVE - SIGNAL/NOISE RATIO.
BERT - BLERT

LOOP BACK MODEL RS232D. (SEE HAND-OUT)
FIG - 16-7 (BUILT IN TEST DIAGNOSTICS IN MODEM)
TESTER IN FRONT OF MODEM
PAGE 349 - PRICES
READ 349 TO 357.
BACK-UP PAG. 354 - BACKUP & ALTERN - PROCEDURE
SPARE LINES ?, SPARE MODEMS ? FOR REPLACEMENT IF
DIAL UP FAILURE
POWER BACK-UP - UNINTERRUPTIBLE POW. SUPPLY.
- BROWN OUT! (DIESEL BACK-UP)
COMMON POWER DISAST.
GEORATOR - ~~RA TE~~ SMOOTHS OUT POWER
DISASTER PLAN MUST HAVE - BANKS. ETC.

SYSTEM MANAGEMENT

CHAPT - 17

TRANSACTIONS
DISTRIBUTED APPLICATIONS - NETWORK ARCHITECTURE
PAGE 365 FIG - 17-1 (SNA) (1970)
FIG - 17-2 SHARE LOAD - (MINI'S)
FIG - 17-4 - COMMUNICATE DOWN - UP BUT
NOT ~~DOW~~ UP TO DOWN

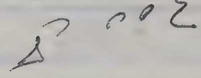


FIG-17-5 - MESSAGE SWITCHING GOING OUT - REPLACED
BY ELECTRONIC MAIL
FORMATS - FADING AWAY (READ UP TO 380)

CHAP - 18 DESIGN

DESIGN FOR USER - NOT TECHNICAL
CENTRALIZED - DE-CENTRALIZE
PAGE 385 IMPORTANT LIST OF 11 POINTS

#4 RESPONSE TIME ... X SECONDS Y% OF TIME
VARYING RESPONSE TIMES AS SYSTEM LOADS UP

PAG 386 - RESPONSE TIME
392 - TRIB -
394 - FORMULA

ALL NETWORK DESIGN IS
ESTIMATES - BALLPARK VALUES.

WINDOW PERIOD
PROBLEM 3-5 AFTERNOON PEAK PERIOD (8 BITS/CHR.)
5000 MESSAGES ... AVERAGE 150 CHAR. (1200 BITS)

5000
1200
6 000 000 BITS
4800BPS = 1250 SEC.

3-5 HRS = 7200 SECONDS.

$\frac{1250}{7200} \approx 17\%$ UTILIZATION

CHAPT- 19

Data Communications

A User's Guide

by

Dr. Ken Sherman

Supplement / Dated - October 1986

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Table of Contents

ISDN

The subject of ISDN is one of the hottest technical subjects in the country today. There is a substantial amount of literature being published almost every week, and there are announced tests in various parts of the world. Before describing the attributes of the ISDN specifics, one must take a look at the concept and then get an idea of how the service will provide some form of advantage over existing transmission network capabilities.

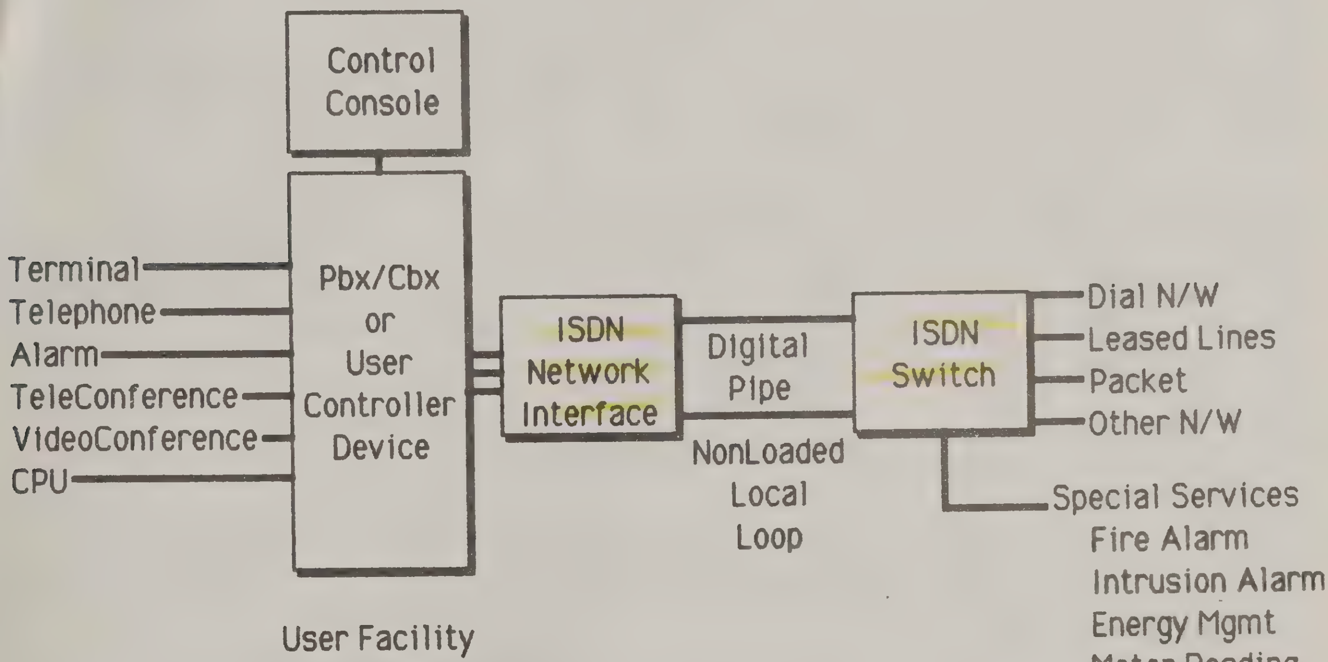


Figure A - 1

If you look at Figure A-1, you will see the concept of ISDN as a "Digital Pipe". There will be a standalone interface (which will be described later) on the user's site. Inputs to that interface will consist of potentially digitized voice (telephone), data, PBX outputs, alarms, local area networks (LAN's), and, in the future, imaging which will probably include various forms of video.

All of these functions will go through the user's site interface, then through the "Digital Pipe", which will probably be T-1 compatible (which will be described later) that will terminate in the local telephone company central office. That office has to be capable of accepting the type of signal which will be transmitted from the user sites. Since many local telephone companies will be upgrading their switching equipments, the availability of ISDN to more locations will be growing all the time, but you should still be aware that

many areas, especially suburban and remote, may not have the appropriate switch for ISDN for quite a few years to come.

Once the signals leave the local telephone carrier switches and are required to cross a Local Access and Transport Area (LATA) boundary, they must be handled by a long-distance carrier. Many of the long-distance carriers intend to provide ISDN services, but not all of them will provide the same level of service, and therefore information may be moved via many different methods. Some of these include circuit switched networks, packet switched networks, database type services, alternate networks, and alternate services. It is also possible that within a particular LATA the local telephone company can provide the same kind of services through their own unique ISDN facilities (more about this later).

The potential ISDN services for the various types of communication are listed below:

DATA	IMAGE	VOICE
Packet Switching	Imaging	Dedicated Lines
Circuit Switching	Cable Television	Digitized Voice
Dedicated Lines	Graphics	Voice Response Services
Electronic Mail	Surveillance	Music
Alarm Services	Picture Retrieval	
Telemetry	Facsimile	
Database Access	Teleconferencing	
Teletext		
Videotex		
Telex		
TWX		
Utility Meter Reading		

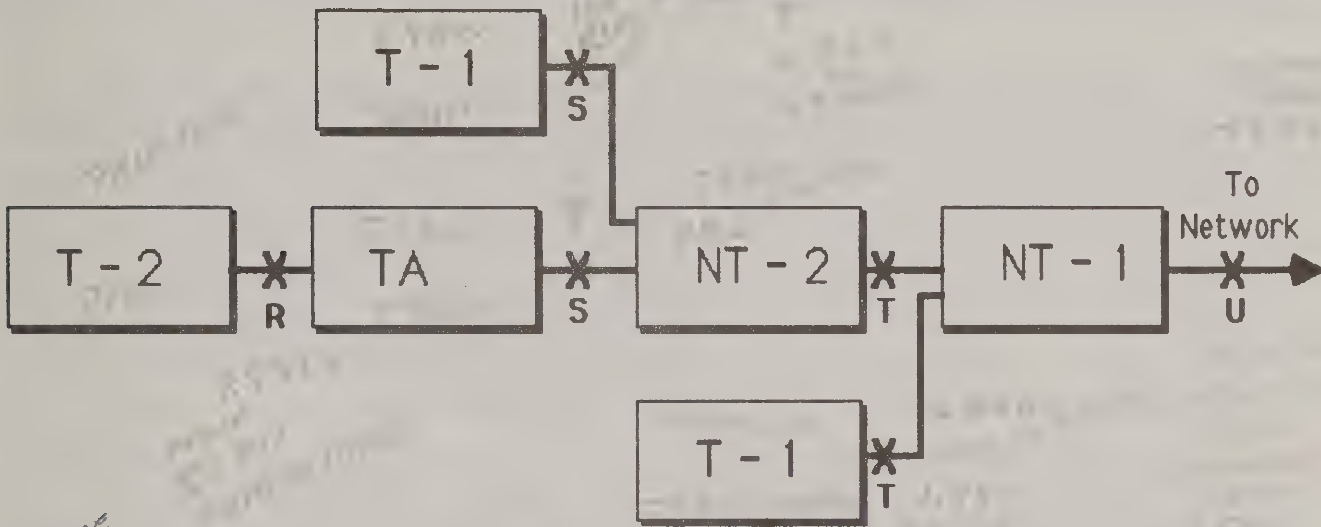
Users will be able to access any or all of these services as ISDN is implemented to greater levels of capability.

Before going into the specifics of ISDN with its associated services, you should become aware of the interfacing that is specified. Figure A-2 shows the standardized specification interfaces.

First of all there are two types of terminal. T-1 is an ISDN compatible terminal which could possibly be a digital telephone set or an integrated voice/data terminal. This particular device may tie directly into an NT-1 interface device (described later) or, could plug into an NT-2 type interface (also described later).

The second type of terminal, T-2, is one that would require a terminal adapter in order to plug into an ISDN interface. A typical example of this would be an RS-232 type device.

If such a T-2 device is the one that you have it must plug into a terminal adapter, TA, which is designed to convert existing interfaces into an ISDN compatible interface. It is possible for the NT-2 device to contain that conversion capability internally, and therefore obviate the need for a separate TA device.



INTERFACES

Figure A - 2

The NT-2 device is an intelligent device that may contain many different types of user oriented connections (S and T). Typical examples of an NT-2 are a PBX/CBX or a cluster terminal controller.

Finally, the NT-1 device is the network termination device which contains all of the necessary interface capabilities to communicate with the network. In other words this device terminates the local carrier's loop which is the connection to the switching office. As such NT-1 provides an interface to isolate the user's internal operation from the operation of the network technology.

The different types of physical interfaces are also specified here and they start with the R type. The R interface could typically be RS-232 or a V type or X type CCITT interface. There will, in all likelihood, be a significant amount of terminal adapters coming onto the market to make it easier for the end user to interface with ISDN utilizing existing terminals.

The S type interface is an ISDN compatible interface and will be used primarily for combining many different user lines into a single controller device like a PBX/CBX. The T interface, also an ISDN compatible interface will then provide the connection to an NT-1

device for a single point of connection to the network. As can be seen the T1 type terminal can be connected either through an NT-2 or an NT-1 device to the network.

The U interface is the one specified between the user's facility and the carrier. Various types of connectors as well as the quantity of lines are still being discussed relative to the S, T, and U interfaces, so there is still a potential for incompatibility at those locations.

There is an even larger problem of compatibility, and that is, where the demarcation between the network and the user's equipment physically rests. In the United States, the FCC has specified the U interface as being the location where the demarcation exists, while the CCITT has been pushing for the S interface. The FCC would like to see competition for the customer premises equipment (CPE) while in the CCITT world, they would like to see the network extend as far into the customer's world as possible because of the government control of the networks in Europe. Although there may be a compromise at the T interface, it is also quite possible that ISDN will end up with two separate interfaces, one for the U.S., and one outside the U.S.

Finally, there will be a single device that will contain all of the functions within both the NT-1 and NT-2 network termination devices. This will combine the cluster controller type function with the network interfaces, and this termination unit will be called an NT-12. A typical example of this device would be a CBX with a direct network interface.

On a simpler level, you can interface either existing terminal-type equipments, telephones, or any other existing device through an appropriate converter so that it is in the appropriate form and format to connect to the ISDN circuit, or you can obtain newer ISDN compatible devices which do not require that type of conversion. The bottom line here is that ISDN will allow upgrades from existing equipments as well as compatibility with newer custom-designed devices.

With the above information in mind, a little history of ISDN is in order. There are really two anticipated generations of ISDN, with the first covering the period 1986 through approximately 1990. During this time, the CCITT will issue standardized equipment interfaces and establish the criteria for integrated voice and data access to the network. Firmer standards are expected by 1988, although there will be continually evolving standards for many years to come. The primary feature of this generation is that there will be more customer control of the feature availability for tying into the ISDN network.

In a second generation of ISDN, which will start in about the 1990 timeframe, the user will begin to see the high-speed service availability of both video and highspeed data. There will be more of the integration of both circuit and packet switching, and there will

be newer services that, in all likelihood, will be driven by the end-user's need for newer/faster services.

Of the standards that have been set, the two that seem to be the firmest are what are known as the Basic Access Interface (2B+D) which is a 144 kbps service. This service involves two channels at 64 kbps (called B channels) and a single 16 kbps channel for signaling which is known as a D channel.

The second definition is for a Primary Access Interface which is called 23B+D. This is a 1.544 mbps path which is broken up into twenty-three 64 kbps channels for information and a single 64 kbps channel for signaling. It is interesting to note that for the 2B+D and the 23B+D the D channel is for signaling in both cases, but in the Basic Access it is 16 kbps while in the Primary Access, the same designated D channel is now 64 kbps. This has been causing a lot of confusion and will probably continue to do so until users are more familiar with the two types of access.

At the moment there are quite few companies that are providing switches for direct access between the user's site and the local telephone company offices. They are ATT with their *5-ESS, GTE with the GTD-5EAX, Siemens-EWSD, NEC-61E (NEAX61), Northern Telecom - DMS100, Ericsson - AXE10, ITT - System 12 (no longer available in the United States), and Stromberg-Carlson. Even though these switches do provide the necessary hardware for interfacing with ISDN, you should be aware that without the appropriate software for signaling purposes, inter-office switching for ISDN applications will not be available. This is one of the big potential problem areas with many tests going on today in different states, because the local ISDN interfaces may not be compatible once they are connected through the long-distance network. In this regard, it is anticipated that Illinois Bell will have the necessary Generic Software for their *5 switch sometime late in 1987. This really means that in order for users with the *5ESS to have true inter-office ISDN transmissions, it will not be available until sometime in late 1987 or 1988 at best.

To add to the confusion of definitions, AT&T has announced a new service which they say goes beyond basic ISDN, and they call it the Universal Information Service (UIS). Conceptually, this is a universal type port which offers a dynamic allocation of network resources for all kinds of transmissions, whether they be data/voice/video/etc. In order to use this service, ISDN would provide the necessary path for the user to go from their own site, through the local telephone company, and then be able to access UIS for long-distance network services.

DIGITAL TRANSMISSION REQUIREMENTS

Prior to describing the details of ISDN-type transmissions, it is necessary to review the methodology of transmitting signals in a digital form. The first digital T carrier systems were provided by AT&T in 1962 for high-speed network trunking of voice

transmissions. Voice was converted through a device called a Codec into a binary bit stream which required 64 kbps transmission (described in more detail later). These 64 kbps paths were called "To" channels and twenty-four of them made up a T1 channel. In order to multiplex these into higher and higher transmission rates, there was an evolution of what were called "channel banks" which were nothing more than sophisticated digital multiplexers. D1 through D3 channel banks evolved from 1962 to 1973 and handled the 1.544 mbps /24 channel digitized voice transmissions. The D4 channel bank first came out in 1977 and could handle either two T1 channels at 3.152 mbps or four T1 channels at 6.312 mbps. This allowed either forty-eight or ninety-six separate 64 kbps channels. There is a new D5 channel bank which will be available any time now, but to date the capacity for transmission has not been specified.

Originally, the first D1 channel bank was not compatible with the D2 through D4 channel banks, but AT&T retrofitted some of the D1 channel banks (and called them D1D) which was then compatible with the higher level channel banks. This means there may be facilities where, even though D1 channel banks are available, they may not be capable of handling ISDN-type transmissions, and you must check this with your local carrier for each of your facilities. A table of the speed verses transmission-type for digital transmissions is provided below.

Transmission Type	Data Rate (in mbps)	Digital Signal Designation	Number of Voice Channels
T1	1.544	DS - 1	24 - pcm/48 - adpcm *
T1C	3.152	DS - 1C	48
T2	6.312	DS -2	96
T2 fiber	12.624	DS-2	96
T3	44.736	DS- 3	672
T4	274.176	DS -4	4032

* pcm = pulse code modulation - requires 64 kbps for digitized voice.
adpcm = adaptive differential pulse code modulation - requires 32 kbps for digitized voice.

With the various channel banks in place and the growth of high speed transmission on the long-distance network, the viability of digital transmission grew. There were some digital services which were provided starting in the early 1980's, and prior to November

1983, all of those digital services were terminated by the local phone company which provided a Channel Service Unit (CSU) which was called Network Channel Terminating Equipment (NCTE). This device provided the necessary line equalization, signal shaping, and line loopbacks for testing the circuit between the carrier and the user's site. Also necessary was a device called a Digital Service Unit or Data Service Unit (DSU) which took the RS-232 generated signal and converted it to the necessary bipolar pulses for digital transmission. The DSU and the CSU were also available in an integrated unit which was the Western Electric 500A when provided by AT&T.

In October 1981 the CSU was established as the sole standard interface for digital services, and the DSU was broken out as a separate unit called the Western Electric 500B. This means the DSU can be obtained from a vendor other than the telephone company.

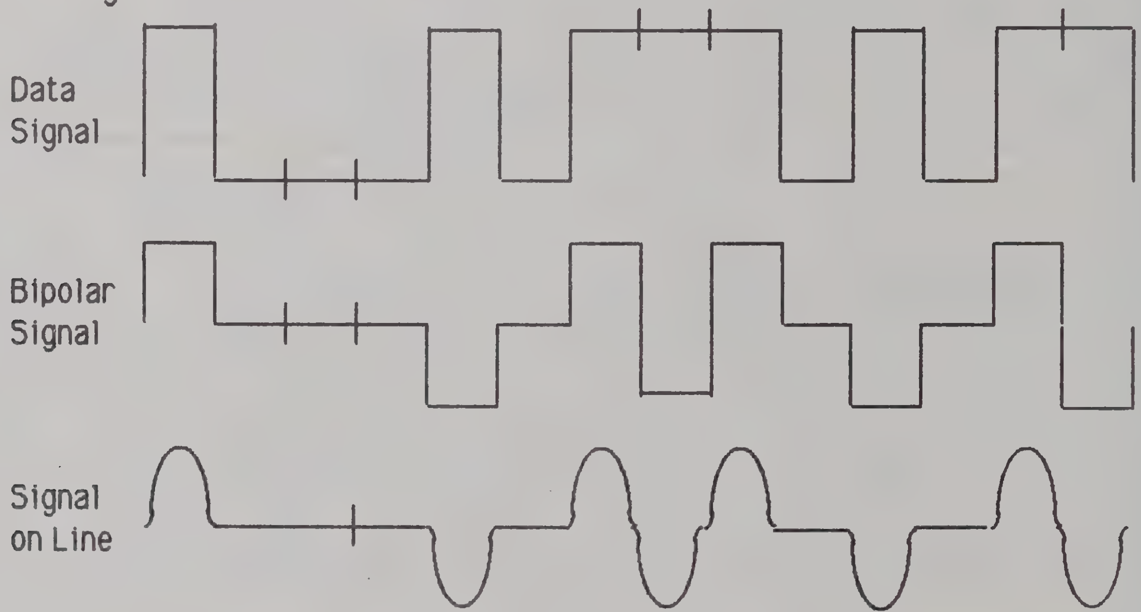
The digital service originally offered by AT&T was called Dataphone Digital Service (DDS) which, for the first time, guaranteed an error rate for a data communications line. The number provided was 99.4 error free seconds out of every hundred, which comes out to 4.4 hours per year. This compared with an anticipated analog error rate of one bit in error for every 10^5. For 128 character blocks this meant a block error of 1 out of 97 for analog and 1 out of 1,800 for digital, when both of them are transmitting at 9,600 bps. In addition, AT&T set up automated test locations for the digital service called ABATS (Automated Bit Access Test Systems) which could monitor and diagnose each user's digital lines. Troubleshooting could therefore be initiated from centralized locations and network reconfigurations could be performed when circuit segments, other than local loops, were found to be malfunctioning. The digital transmission rates were 2400 bps, 4800 bps, 9600 bps, and 56 kbps. The service was provided on existing lines where appropriate signal regeneration equipment could be installed on local loops and the local telephone company class 5 switch could accommodate the digital signals. The latter was done by incorporating digital line cards in existing switches or installing new switches.

Eventually, because of the multiple vendors developing both hardware and software, the need for a standardized digital type interface evolved, and we entered into the T1 world at the user location and then ISDN.

T1 SERVICES - 1.544 mbps

As a base from which digital transmissions would evolve, the T1 transmission rate was selected. Since 1.544 mbps at 24 channels of 64 kbps had been used for so many years, and the entire U. S. long distance network was based on T1 and its multiples, it was only natural to use it as a base, but it is very much different in Europe where the T1 equivalent is 2.048 mbps and provides 32 channels of 64 kbps each. Therefore, right at the start there is a significant incompatibility between the T1 rates and a specific resolution as to how to handle this situation has yet to be finalized.

The T1 transmission rates can be implemented on different media. For 24 gauge twisted pair copper wire, the signal (to be described later) must be regenerated approximately every mile up to about 100 miles. Beyond that distance, there is a potential timing problem which may result in loss of synchronization. A second form of media which can be used with T1 is coaxial cable which can be used with specially designed modems which operate at 1.544 mbps information flow. Fiber optic transmission can be used especially where many T1 channels must be multiplexed together. In today's fiber world, the electrical signal needs to be regenerated approximately every 7 - 20 miles with the eventual capacity expected to go well over 1 gbps. Direct microwave transmission can also be used, and it can be either analog microwave for short distances of up to two miles and carrying one to four T1 lines, or it can be digital for longer distances (carrier world) and may consist of many T1 lines. Anyone of the above methods may be used to connect user locations directly together, or the user can be connected to one of the carriers using one or more of them.



Bipolar Transmission

Figure A - 3

Since T1 transmission is so important to ISDN, a more detailed look at its mechanization is warranted. Figure A-3 shows the bipolar pulse which is generated for all digital transmissions. The primary characteristic of this pulse sequence is that the pulses only occur when there are "1" bits, and they alternate polarity. The rationale behind this kind of operation is two-fold. First of all, the bipolar pulse itself eliminates the DC content of the electrical signal as it travels down the transmission path, so transformers can be used for coupling purposes. The second reason is that if an extra pulse is generated due to noise somewhere, or, alternatively, if a pulse is lost, it is easy for the next location of receiving hardware to detect that an error has occurred in the transmission. This

detection takes place prior to the user's software getting involved and is an excellent way to detect errors during the transmission itself.

The characteristics of the pulses are that they are nominally three volts (2.7 - 3.3 Volts). In T1, clock time is every 648 nanoseconds (ns), while the pulse-width itself is 324 ns. There must be at least one "1" bit every fifteen bits and at least three "1" bits in every 24 bits.

In the T1 transmission itself there are a total of 24 channels, each one comprising 64 kbps. The transmission is divided into frames and superframes. A frame is 193 bits long with eight bits from each of the 24 channels plus an extra "framing" bit as the 193rd bit. A superframe is a repeating sequence of 12 frames that includes 12 special synchronizing bits for frame synchronization and voice band signaling information. The voice band signaling information is contained in the least significant bit of the sixth and twelfth frames (taken from the digitized voice information). This is shown in figure A-4. It should be noted at this time that if actual data is sent (not digitized voice) this "bit robbing" cannot be done, and therefore, digital data must be sent at a rate of 56 kbps maximum. That is why the terms 56 kbps and 64 kbps are sometimes used interchangeably. In the case of digital data, the extra 8 kbps is utilized for the synchronizing and signaling information that would otherwise be removed from the digitized voice. When the least significant bit of every sixth and twelfth frame is removed from digitized voice, the impact on the quality of the voice is negligible. For data, however, it would be disastrous because you would be eliminating real data bits.

In order to be compatible with T1 signaling, you must transmit and receive in accordance with AT&T publication 62411 dated 9/83. This document will tell you all you need to know about the signaling in the event that you would want to design equipment to transmit to, receive from, or interface with other T1 compatible equipments. All potential users must be aware that T1 capability is not available in all areas, and in some states, not at all. AT&T has stated that at the end of 1986 only 60% of their offices were T1 compatible.

There are other areas where the potential user may be affected by upgrades in the T1 capability. For example, a new compression mechanism called Adaptive Differential Pulse Code Modulation (ADPCM) is available but may not be widely used by local telephone companies because it is incompatible with D4 type channel banks. This form of compression is known as M44 and consists of four separate channels of 384 kbps each, called bundles. Each bundle has eleven ADPCM digitized voice channel and one control channel. Therefore, if T1 is utilized this way, it is capable of carrying 44 separate digitized voice channels(plus 4 control channels) instead of 23 and 1 for standard T1, but if not widely available in your particular area, it may be of academic interest only.

Frame Number	Ft Terminal Framing	Fs Signalling Framing	Superframe Formats
1	1	–	1
2	–	0	0
3	0	–	0
4	–	1	1
5	1	–	1
6	–	1	1
7	0	–	0
8	–	0	0
9	1	–	1
10	–	1	1
11	0	–	0
12	–	1	1
13	Same Pattern Repeated Every 12 Fames	Same Pattern Repeated Every 12 Fames	Same Pattern Repeated Every 12 Fames
14			
15			
16			
17			
18			
19			
20			
21			
22			
23			
24			

Ft – A fixed pattern of 1 & 0 bits carried in the 193rd bit of each T-1 frame and repeated every 12 frames.

Fs – Indicates to the receiving channel bank that certain frames contain signalling bits. Signalling bits are "robbed" from transmitted information to send control information like on/off hook, termination, dialing, etc.

Superframe – D4 framing format.

Transmission Framing

Figure A-4

Obviously, you can't have a T1 frame and superframe in the M44 type transmission. In addition, the T1 transmission method of integrated 24 channels must occur on the circuits from the customer to the local telephone company switching office. The signaling must therefore include the sixth and twelfth frame signaling bits which are known as A and B bits. These bits are used to send circuit information like on/off hook, busy, dial info, etc. In the future this may need to change because AT&T uses the separate 24th channel for signaling information on the long distance network. This is called "out-of-band" signaling and will be one of the requirements of ISDN. The

Frame Number	Superframe Format Value of F-Bit	Use		Extended Superframe Format (ESF) Value of F-Bit		Use
1	1	F_T		I		D
2	0		F_S	I		CRC
3	0	F_T		I		D
4	0		F_S		0	F_S
5	1	F_T		I		D
6	1		F_S	I		CRC
7	0	F_T		I		D
8	1		F_S		0	F_S
9	1	F_T		I		D
10	1		F_S	I		CRC
11	0	F_T		I		D
12	0		F_S		1	F_S
13				I		D
14				I		CRC
15	REPEAT			I		D
16					0	F_S
17	OF			I		D
18				I		CRC
19	FIRST			I		D
20					1	F_S
21	12			I		D
22				I		CRC
23	FRAMES			I		D
24					1	F_S

FT - Terminal Framing Bit } F-Bits
FS - Multiframe Alignment Bit }
I - Information Bit
D - Data @ 4 KBPS - M-Bit
CRC - Cyclic Redundancy Check Bit - C-Bit - 2 KBPS LINK BY LYNK CHECK FOR ERRORS

Superframe and Extended Superframe
F-Bit Designations
Figure 16-10

REPLACES
BLUE BOOK FORMAT PAGE 10

USE 193 BIT

methodology for providing the signals in this 24th channel for ISDN is called Signaling System *7 (SS *7). Also for the future, the AT&T computer to PBX interface, which they call DMI (Digital Multiplexed Interface), will have this out-of-band signaling.

SIGNALING SYSTEM *7

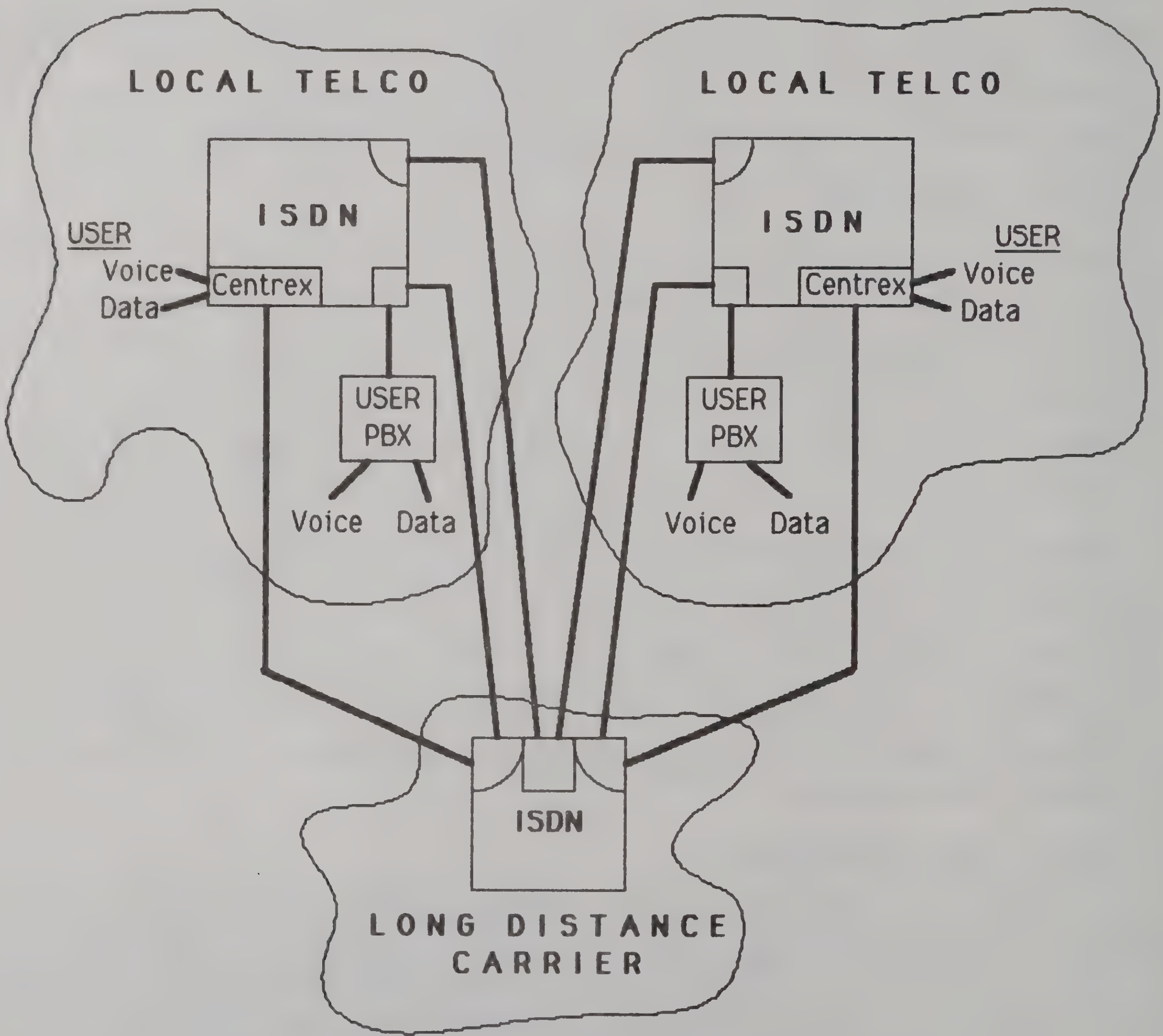
Signaling System *7 will be the mechanism whereby various telephone offices can signal each other to complete a call being made through an ISDN connection. That is not to say that only ISDN will use SS *7, but it will be required for ISDN. SS *7 will support all necessary call establishment and disconnect functions as well as billing, financial administration, and connection supervision overhead. The software necessary to provide SS *7 will be very fast, accurate, reliable, and each phase of a call for a dial connection will be handled separately. In other words, the call establishment, the conversation itself (data included), and disconnect will be handled by sending control messages between the various switching processors as opposed to looking for mechanical or electrical connections.

When SS *7 is implemented, the end user will have access to the full B channel of 64 kbps without the necessary "bit stealing" for controls of that channel. This is sometimes known as "clear channel" operation. By utilizing the separate D channel for signaling, a connection can be established or modified quickly with respect to its destination and characteristics. Data can be sent without disturbing existing connections, such as with a packet. This eliminates all of the negatives of in-band signaling, not only for providing the clear channel, but also preventing the use of external equipment to utilize the long-distance network without paying for it (the blue boxes of old). This separate D channel signaling will be used for the path control between the user site and the ISDN network. The protocol for messages used on this channel is known as Link Access Protocol D (LAP-D) which is a modification of the LAP-B utilized in X.25 specifically for ISDN type functions. LAP-D has fewer options than LAP-B because it is designed for a very specific type of interface. As a direct consequence of SS *7 there will be a different kind of signaling from the user site to the local telephone company central office. This will be called Q-931 signaling which utilizes the A and B bits described previously.

TYPE OF ISDN CONNECTIONS

In attempting to set-up ISDN connections between multiple telephone company offices (available in 1986 only under very limited conditions - no SS *7) you can see the type of connections in Figure A-5. These connections are for interLATA communications which will be the heaviest use for ISDN. On an intraLATA basis, a local telco can set-up its own form of connection, which may or may not be compatible with the long-distance carrier. This is the biggest area of potential incompatibility for ISDN. The user would like to communicate between logical devices (computers/terminals/etc.) and is looking toward ISDN as a means for providing that path efficiently, along with voice circuits

that must be available between the same locations. For that reason, the T1 local loops should be selected with special care. For example, the wiring should not be put in the same cable as analog signals because the ringing signals on analog circuits can cause errors on the adjacent digital lines. The T1 digital pairs must also be carefully balanced for impedence so that the signal distortion does not degrade to the point where the signals will not be recognizable. Also, the transmit and receive pairs from each circuit should be isolated, and if there are any bridged taps, they must be removed. A bridged tap is a connection which was made to the line in the past but has subsequently been



InterLATA ISDN Connections

Figure A-5

disconnected as far as the instrument is concerned but not as far as the connection to the line is concerned. The degradation to impedence of that unused and improperly terminated connection will distort the T1 signal to the point where it may not be recognizable.

T1 on a dedicated basis is rarely economical at distances greater than 500 miles. Although the physical circuits can be the same as those used for analog circuits with their loading coils removed, they must have regenerators which recreate the signal about every 6,000 feet. For higher speed transmissions the regenerators must be placed approximately 3,000 feet apart (1 km).

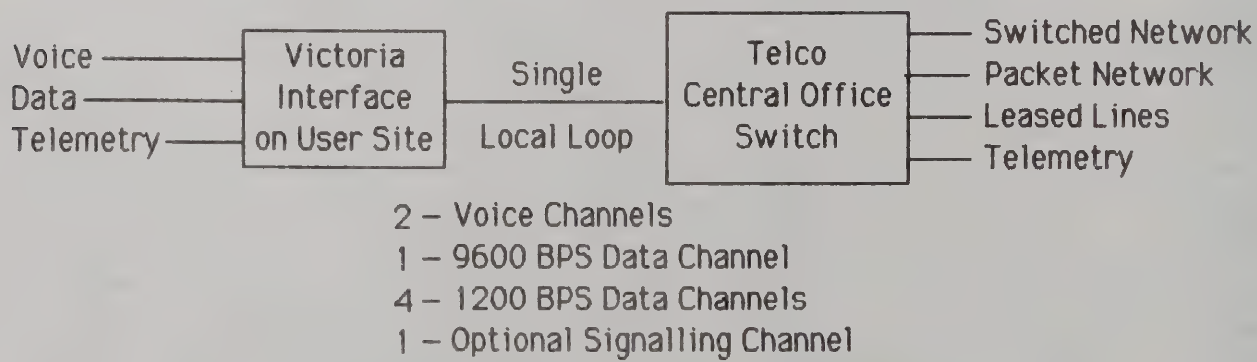
RELATED INFORMATION

Although the B and D channels have been defined and are in the process of implementation, there is also another channel, called the H channel. This H channel will be used for high capacity transmissions such as video. The H channel comes in a couple of different variations. First of all, there is Ho which is 384 kbps. It can handle packet switched data, facsimile, video, high speed data, and high quality audio, but has no signaling capability. There are also non-channelized multiples of the Ho channel. They are H11 which is 1536 kbps and H12 which is 1920 kbps. Non-channelized means the user has access to the full bandwidth. For channelized multiples of Ho there is a 1216 kbps channel that is divided up into three Ho channels plus one D channel. All products which indicate they are ISDN compatible should be upgradable to handle the various H channels.

For those of you who are considering DDS type transmissions on a T1 or ISDN network, you should be aware that DDS bits are replicated on the backbone AT&T network which gives those transmissions their high degree of reliability (99.4 error-free seconds out of every 100 seconds). Since T1 is rated to be approximately 95% error-free, when DDS transmissions are sent via T1 transmission paths, there will be some degradation with respect to errors. Also, for DDS transmissions which are sent in T1 subchannels (T0 - 64 kbps), the last bit of each eight bit sequence must be set to a "1" to tell the receiving T1 processor that the other seven bits are really customer bits. Those T0 channels which contain DDS data do not carry any in-band signaling status bits (A and B) like voice does. For 9.6 kbps and less transmission rates, the first bit in each eight bit sequence is also required for control which leaves six bits for customer use. This first bit is called the sub-rate framing bit, and a special bit pattern in consecutive time slots identifies the transmission rate as being 9.6, 4.8, or 2.4 kbps. A separate piece of hardware is required to handle these sub-rate transmissions, and a maximum of five sub-rate channels of 9.6 kbps can be handled on a single T0 channel.

Of all the ISDN tests that are in process today, the primary feature seems to be the ability to communicate across a T1 channel between multiple locations and devices. In reality, however, there are no tests which, at present, communicate via a switched

connection between telephone company offices. As was stated previously, this cannot occur until Signaling System *7 is implemented, and this will not be until late 1987 or 1988. What is it, then, that is being tested? The hardware and the interfaces between the user's site and the local telephone companies are what is being installed. These are all being done in anticipation of future evolution to a standardized ISDN network. The problem with this philosophy is that many of the local telephone companies are installing ISDN services for their local customers and the interfaces may not be the same for other telco's. Neither is the interface with the long-distance carrier standard. Still, there may be a lot to be gained by trying these new connections, but, at the same time, you must realize that they may only be good for communicating within a single LATA. If you want to be a pioneer and hope that the inconsistencies will be worked out, then you are a prime candidate for one of these tests. One of the more interesting of these tests is Project Victoria from Pacific Bell in California. A diagram of this test is shown in Figure A-6. On a standard local loop in Danville, 200 users will have equipment installed at their sites (residential and business) which will accommodate two digitized voice channels, one FDX 9.6 kbps data channel, four FDX 1200 bps data channels, and an optional signaling channel. This conforms to a smaller CCITT 1B+D standard which is a total of 80 kbps (64 kbps + 16 kbps). The voice channels are 32 kbps ADPCM and the single 16 kbps data channel is divided into the single 9.6 kbps and four 1.2 kbps data channels. The 2B+D standard (basic rate of 144 kbps) will be made available as soon as possible. The primary use of this particular service is for telecommuting and interoffice communication where the ISDN line will replace the separate lines which are presently running for those services now.



Pacific Bell's Project Victoria

Figure A-6

The multiplexer on the customer site integrates all of the local paths, and the Pac Bell central office will split them out to be routed independently throughout the rest of the network. This test is being described as an ISDN test but will have a wider application if more end user's find the service economically viable.

This also points out some of the other ISDN attractions. They are the reduction in requirements for total modems, reduction of the amount of internal coaxial cabling required to connect devices, and a reduction in the 25 paired cables which link office phones at present. Station moves can be made very easily because there is only an addressing scheme involved, and this can be handled in software. Ultimately, even Personal Computers can be tied into ISDN as there is no doubt an interface card will be developed to do just that. This process will be the same as a protocol conversion which is already being done, and ISDN can be looked at as being just another type of interface.

Finally, if ISDN is going to implemented at the local telephone central offices, it will strengthen the viability of Centrex service because many of the connections can be done right at the telco office instead of on the customer's site utilizing customer resources. Eventually, this may mean the requirement for on-site PBX's will be reduced.

Also, because of the digital nature of the ISDN transmissions, they are more amenable to encryption for sensitive transmissions. It is, therefore, quite possible that, in the future, users will be able intermix both clear and encrypted transmissions for those applications which require them. Although there is very little doubt that ISDN is coming, there is significant doubt as to what the final standards will be. Therefore, if the end user decides to implement ISDN now, he is taking a very big chance that, in the future, compatibility may not exist at both ends of a long-distance connection. This should be a "buyer beware" situation such that if you decide you want to go ISDN now, you recognize what the potential problems will be later.

MODEMS

The world of modems has been changing significantly in the last few years with the speed increasing, costs coming down, and new technology being added to improve the effective information throughput.

First of all we have the speed increases. Modems today are capable of operation at up to 9600 bps in a full duplex mode on a dial up circuit. At the same time there are other modems that can operate up to 19.2 kbps on leased D1 conditioned lines. To support these types of operation, the CCITT has come up with a set of specifications that describe the operation of the modems at those speeds. Table B-1 describes the new specifications as well as the older ones for lower speed, all on one chart. This chart now replaces the two tables listed in the text on pages 190 and 191. What is included is both the CCITT specs (V series), as well as the ATT equivalents. This table can be used for comparison purposes, but it should be noted that just because the parameters appear to be the same, it does not necessarily mean that two modems are compatible. There is compatibility between the 212 modem operating at 300 bps and the 103 modem, as well as the V.22 modem operating at 1200 bps and the 212 modem operating at 1200 bps. Where the problem enters is during the "fallback mode" where the 212 will operate at 300 bps while the V.22 will operate at 600 bps. This kind of situation will also exist with the V.22 BIS modem in the fallback modes. Therefore, the user must know ahead of time which primary and fallback speeds they want to use and then make sure the modems at both ends of the line are compatible with each other.

As can be seen, the higher speed specifications such as V.29, V.32, V.33, and V.35 are more thoroughly defined now. This will provide a basis for compatibility between different vendor products at these higher speeds. It appears at this time that most vendors are designing their modems to be compatible with the spec at these speeds, but there are also some vendors who are utilizing their own proprietery techniques which might cause problems in the future if new sites are to be integrated into a network.

The new technologies that are being added are twofold. First there is better equalization and filter circuitry which allows the modem to optimize transmission for any given line connection. The chips that are being developed today allow this equalization to take place at a faster rate for a lower cost. Secondly there is the use of data compression techniques within the modems themselves which allow what appears to be a higher effective throughput to the user. By compressing character information it is possible to get up to a 50% reduction in the total amount of bits to be transmitted, and this would allow the doubling of the user throughput, while the transmission rate on the line appears to be the same. Lastly, there is a forward error correcting technique utilizing a convolutional code which not only involves a new implementation of this technology, but

Modem Type	Data Rate (bps)	Baud Rate	Modulation Method	HDX/FDX	Carrier Frequency
103	300	300	FSK	FDX - 2 Wire	1070/1270 - orig.
					2025/2225 - ans.
V.21	300	300	FSK	FDX - 2 Wire	980/1180 - orig.
					1650/1850 - ans.
202	1200	1200	FSK	HDX - 2 Wire	1200/2200
				FDX - 2 Wire	387 Backchannel
V.22	1200	600	DPSK	FDX - 2 Wire	1200/2400
	600	600	PSK	FDX - 2 Wire	1200/2400
212	1200	600	DPSK	FDX - 2 Wire	1200/2400
	300	300	FSK	FDX - 2 Wire	1070/1270 - orig. \ 2025/2225 - ans.
V.23	1200	1200	FSK	HDX - 2 Wire	1300/2100 \ 390/450 Backchannel
	600	600	FSK	HDX - 2 Wire	1300/1700 \ 390/450 Backchannel
201	2400	1200	DPSK	HDX - 2 Wire	1800
				FDX - 4 Wire	
V.22bis	2400	600	QAM	FDX - 2 Wire	1200/2400
	1200	600	DPSK	FDX - 2 Wire	1200/2400
V.26	2400	1200	DPSK	FDX - 4 Wire	1800
V.26bis	2400	1200	DPSK	HDX - 2 Wire	1800
	1200	1200	PSK	HDX - 2 Wire	1800
V.26ter	2400	1200	DPSK	FDX - 2 Wire	1800
	1200	1200	DPSK	FDX - 2 Wire	1800
208	4800	1600	PM	HDX - 2 Wire	1800
				FDX - 4 Wire	
V.27	4800	1600	PM	FDX - 4 Wire	1800
V.27bis	4800	1600	PM	FDX - 4 Wire	1800
	2400	1200	PM	FDX - 4 Wire	1800
V.27ter	4800	1600	PM	HDX - 2 Wire	1800
	2400	1200	PM	HDX - 2 Wire	1800
209	9600	2400	QAM	HDX - 2 Wire	1650
				FDX - 4 Wire	
V.29	9600	2400	QAM	FDX - 4 Wire	1700
	4800	2400	DPSK	FDX - 4 Wire	1700
V.32	9600	2400	QAM or TCM	FDX - 2 Wire	1800
	4800	2400	QAM	FDX - 2 Wire	1800
V.33	14,400	2400	QAM	FDX - 4 Wire	1800
V.35	48,000	N/A	AM/FM	FDX - 4 Wire	100,000

Modem Chart

Table B-1

also provides the additional reliability in transmission. For example, the Codex 2680 modem operates at 19.2 kbps over 3002 D1 conditioned lines. Normally, a signal constellation of 256 points would be required (6 bits/baud), but with the use of Trellis coding (the form of convolutional coding used) it is possible to get the signal points reduced to 160, even though an additional point has to be added for the forward error correction. The way the modem works is to collect information bits in 28 bit sequences (4 symbols). It does this 2,743 times per second. 3 of the 28 bits are put through a 64 state convolutional encoder that adds an extra bit. Then the 29 bits are mapped into 4 separate signal points selected from a 160 point constellation. At the receive end, when the bit stream is decoded, the demodulator can select the most likely stream of 29 bits that made up the originally transmitted sequence. By reducing the amount of points to be decoded, the receiver can tolerate more than twice as much noise as a non-Trellis coded transmission. This mechanism can reduce the error rate by three orders of magnitude, and therefore gives an extremely high reliability to the reception of information without errors.

Another related area where reliability is being improved is at the low speed end for those transmissions at 1200 bps asynchronous for use with PC's. Since transmissions at these rates are asynchronous, there is no inherent error detection capability like there is with synchronous transmission that use BCC or CRC. As such, some vendors have put the capability for detecting errors at these transmissions rates into their modems. These are sometimes called modem protocols. The two primary schemes are called the Microcom Networking Protocol (MNP) and X.PC.

X.PC is a public domain error checking protocol that is backed heavily by Tymnet for use with their packet switching network. MNP used to have a licensing fee, but in early 1986 Microcom, due to user pressures, decided to make their MNP available for $100 to cover documentation cost. At this point in time there is heavy use of both protocols and it is quite possible that both will exist simultaneously for many years to come.

There is a third protocol which is used by Concord Data Systems which utilizes an ARQ type of retransmission sequence. This is only available with Concord modems, but has a wide usage because of the quantity of Concord modems in the user community.

Even though these modem protocols are available at 1200 bps, as well as at 2400 bps FDX, more than half the modems at 2400 bps FDX in the user community today do not have any error detection capability built into them at all, which is very significant considering the increase in transmission errors which will occur at the higher speed.

While discussing the subject of modems, there are many pieces of information which don't fall into any particular descriptive category, but which the user should be aware of. For example, when utilizing a V.22 BIS modem the "answer tone" is the defined as 2100 Hz. Operation on the U.S. and Canadian networks however require an answer tone of 2225 Hz. The 212 modem has a 2225 Hz answer tone but seems to operate with either

frequency of answer tone, while the V.22 BIS modems don't always recognize the 2100 Hz tone. This means that utilizing a V.22 BIS modem in North America may not be a wise choice.

Also when discussing the V.22 BIS modem, the number of fallback speeds and the format of the carrier handshake to get to that speed is not defined in enough detail to make the fallback reliable. For compatibility with 212 type operation, there must be a fallback to 300 bps which the V.22 BIS does not have. Secondly, the sequence at the RS-232 interface (V.24 for the CCITT) is not the same, and also the auto-dialing command set used to establish a connection will probably be different (CCITT uses V.25 and V.25 BIS which is very unwieldly, while in the U.S. the modem vendors typically use a subset of the Hayes AT command set). The V.25 is for parallel interfaces while the V.25 BIS is for serial interfaces. Also, besides the Hayes command set there is a separate command set established by Concord and ATT Information Systems (ATTIS).

Another potential incompatible area is the "call waiting" feature available in the U.S. Call waiting is provided by a temporary disconnect which lasts somewhere between 50-200 ms. A V.22 BIS modem will drop its carrier detect in 40-65 ms while the 212 A modem will use between 600-700 ms before it will drop its carrier detect signal. This means a V.22 BIS modem may not be usable where call waiting is available.

Another term which you may run into when discussing modems is the "scrambler". A scrambler is used to randomize data before modulation. It is usually necessary to prevent long strings of 0's or 1's from causing the modems to go out of synchronization. Scramblers are used in high speed modems where there are two or more bits per baud. For example, if there are three bits per baud the normal designation for the signal points in the constellation would start off with 000, then go to 001 and continue in a binary sequence until 111 is reached. The scrambler takes the 000 and the 111 combination at a minimum and puts them out of sequence to guarantee that there will always be some phase shift for the carrier output which is not 0° or 180°. Such a continuous sequence of 0's or 1's would be detrimental to a modem which is pattern sensitive to a long string of 0's or 1's.

Modem training time was discussed in the chapter on synchronous transmission, and is the time associated with the demodulator establishing the appropriate clock position on pin 17 of the RS-232 interface with respect to the data on pin 3 at that interface. During this same time the demodulator will also establish the equalization parameters for its filter circuitry in those modems that have automatic or adaptive equalization. This takes place during the training time.

Another term that is being used more and more in the high speed modem world is QAM. This stands for Quadrature Amplitude Modulation and is a unique form for providing carrier modulation. It involves the use of two separate carriers at the same frequency from the same transmitter. The first carrier is a sine wave, while the second one is a

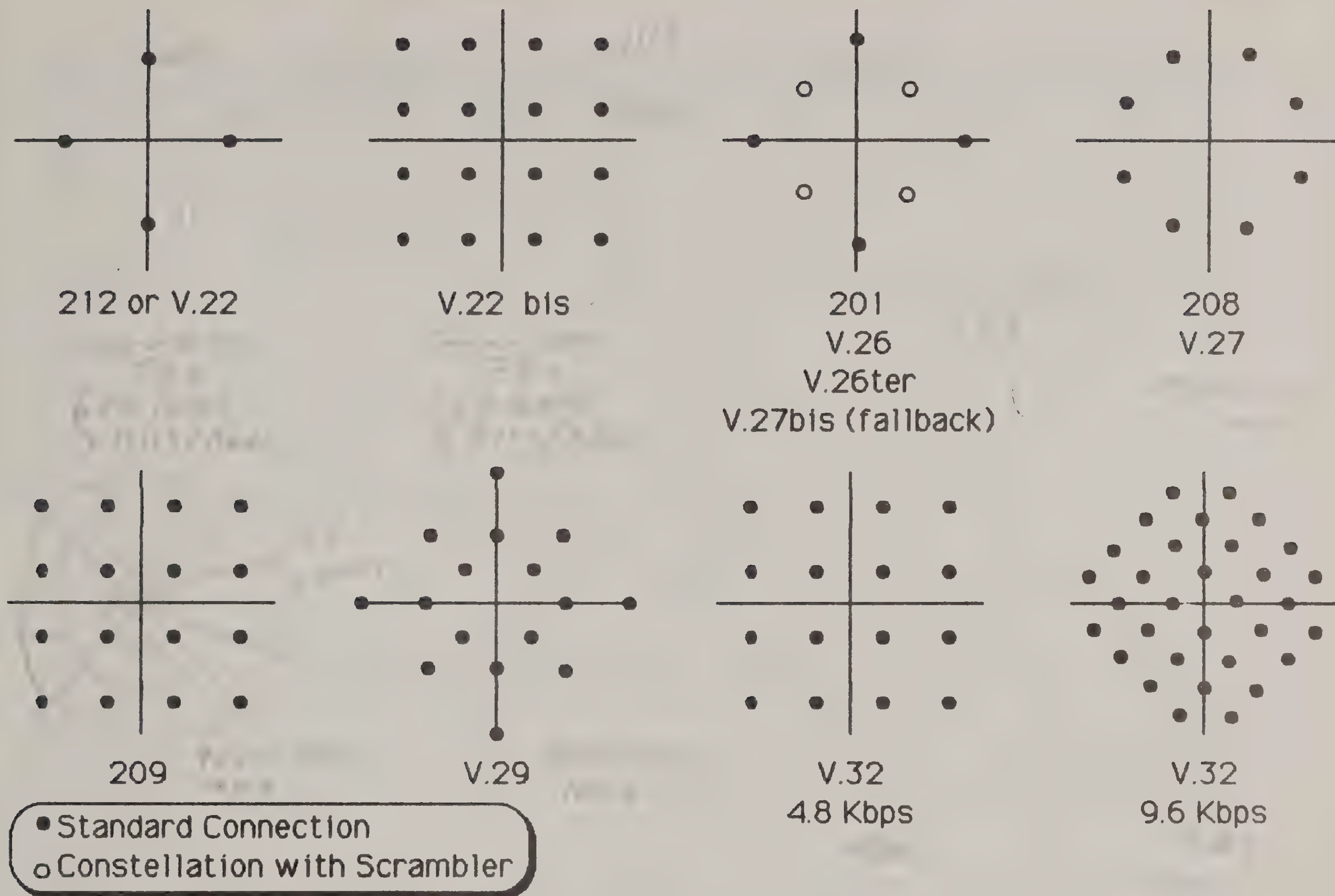
cosine wave. When trying to establish a signal constellation with varying amplitudes and phases, you can take the X axis value and modulate the cosine wave, while at the same time take the Y axis value to modulate the sine wave. At the receive end, both carriers are detected and demodulated to give the specific received signal point being transmitted. Another way to utilize the QAM is in the Trellis coded modulation scheme where, for example, at a 14.4 kbps transmission rate you would normally have 64 states with 6 bits per state. The modem could take 6 bit symbols at a rate of 2400 times a second and take the last 2 bits in each symbol, and encode them utilizing a Trellis code to give a set of three encoded bits. The result is 4 data bits and 3 encoded Trellis bits giving a 128 point signal constellation. The 4 data bits can modify the cosine carrier while the 3 encoded bits can modify the sine carrier. The 3 encoded bits can select 1 of 8 different subsets where each subset is16 bits. Because of the FEC only certain sequences of signal points are valid and the spread between adjacent valid signal points is much greater than if no FEC was used, and therefore there is a much lower probability of errors being generated.

Also, while we are discussing signal constellations you might be interested to see what they look like for most of the standard modems in use today. Starting from a 212 modem and going up through a V.32 type modem you can see the signal constellations in Figure B-1. These "Eye" patterns can be used in conjunction with those on pages 184 and 185 in the text to give you a good overall description of what the various signal constellations look like.

Finally, when looking at the "Eye" patterns, you can also get a good idea of the kind of degradation you are having when data errors are excessive. Some of the impairment effects are shown in Figure B-2.

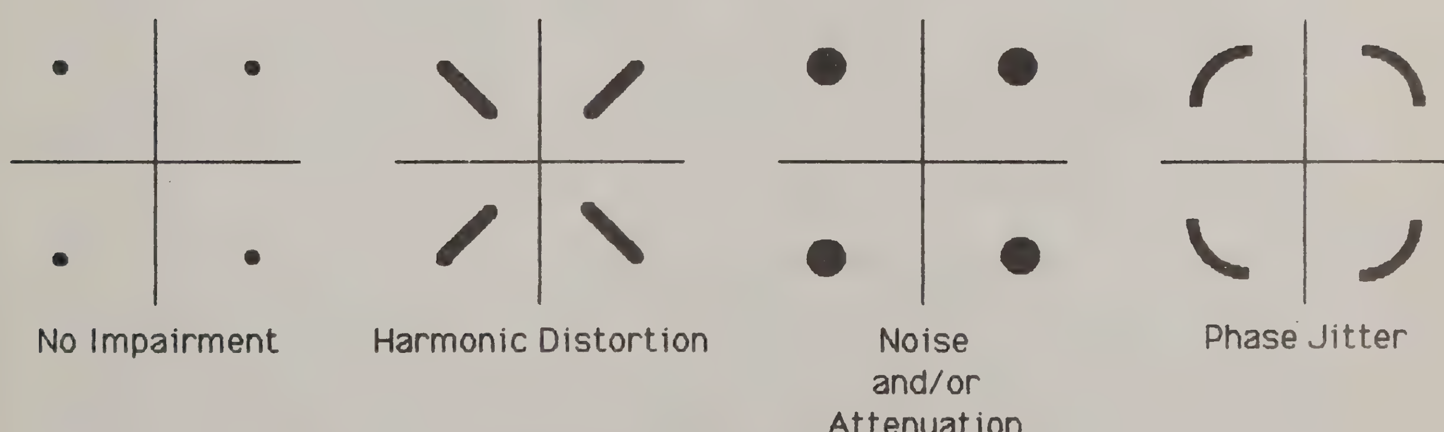
OTHER TRANSMISSION MECHANISMS

In today's data communications world there are other ways to transmit data besides using modems. For example, in the television and FM radio transmission world there is a substantial amount of excess bandwidth called sidebands which are not used. In FM this is called subcarrier while on TV it is called the vertical blanking interval (VBI). These involve a one way transmission only (cannot be used interactively unless you have a Teletext or Videotex service). It is user and distance insensitive as long as you are in the broadcast range of the station transmitter. Typically, sideband transmissions are used to broadcast information, electronic publishing, database distribution, software delivery, education, and most prevalently at the moment, stock quotations. This is a rapidly growing market segment today with the anticipated vendor base being retailers, wire services, database providers, and supermarket chains for shop at home service.
A second form of transmission is called Spread Spectrum. This technique can be used on local telephone loops that,are "unloaded", and can be used simultaneously with voice.



Signal Constellations

Figure B-1



Effects of Impairments

Figure B-2

Spread Spectrum techniques involve the breaking up of the individual bits into bit stream sequences and transmitting pieces of the sequence ("sub-bits") at different frequencies. Even if some of the bits in the generated bit streams are lost, the actual total sequence can be approximated to give you the actual individual bit you wanted to transmit. For example a 1 bit can be represented by the sequence 10010110 while the 0 bit can be represented by 01101001. Obviously, you don't have to get all the bits to make a determination of which sequence would have been received if all of the sub-bits were received correctly. It is like singing a song where not all of the words come through but you recognize the tune. On user owned wire or local loops there is no inherent bandwidth limitation so many different carriers can be used for the sub-bits. This sequencing not only substantially reduces or eliminates the effect of line noise and echoes, but is also an invaluable tool if you desire to encrypt your transmission. An unauthorized intruder would have to have a device which would pick up the specific carriers you were utilizing for transmission. To add another level of preventing unauthorized intrusion, you would add to the sequencing a "frequency hopping" mechanism for putting bits on different carriers at different times. The intruder then would also need to know what the algorithm was for which bits were going to be transmitted on what carrier at what time. This type of transmission will be used primarily for communicating between facilities that are either within an industrial park or within a couple of miles of each other. It is very expensive at this point in time, but in the future it is anticipated to be down in the $500 per end range. The technique is well proven since it has been used in the military world for many years and is now becoming available in the commercial world.

Lastly, if you want to communicate between buildings and there is no way to run a cable between those facilities, you may want to evaluate the use of infra-red. This can take the place of local microwave and is substantially easier to incorporate because there are no FCC filings with their inherent delays. The signal is a baseband digital or analog signal which is modulated onto a high frequency carrier (digital is the most common method). The form of modulation is preferably FM. The modulated carrier goes first to an infrared LED, and then sent to a Solid State Laser where the output infrared beam is modulated. This is good for up to one mile, especially in the 23 GHz range. The speed of transmission is comparable to T carrier rates up to T3 (45 mbps).

Multiple transceivers can be near each other because of the narrow spread of the beam, and the primary use can be for bypassing copper links or for a "final hop" in a local carrier bypass direct to a long distance carrier. One of the considerations in this technique is that the transmitters have to be protected so that humans do not look into the beam because there could be harmful affects to the eye. Each transmitter is labeled with a rating established by the government which indicates the level of potential hazard. This is a concern, but with proper precautions should not be a factor in the decision.

Costs for this type of transmission are becoming very competitive at T-1 rates and are expected to be reduced even further as more units are built.

CANADA

The Canadian data communications industry is much more like the United States than it is Europe. Part of this similarity stems from the fact that the Bell System technology was dominant in Canada through the early part of the 1900's. Today there are many carriers all throughout Canada although Bell Canada constitutes more than half of all telephone operations for the entire country. The structure of the various organizations within Canada is shown in Figure C-1.

In the center we have Telecom Canada which is an association of some of the largest Canadian telephone companies. It is a common carrier which provides public telecommunications facilities and prior to September 1983 it was called the TransCanada Telephone System (TCTS).

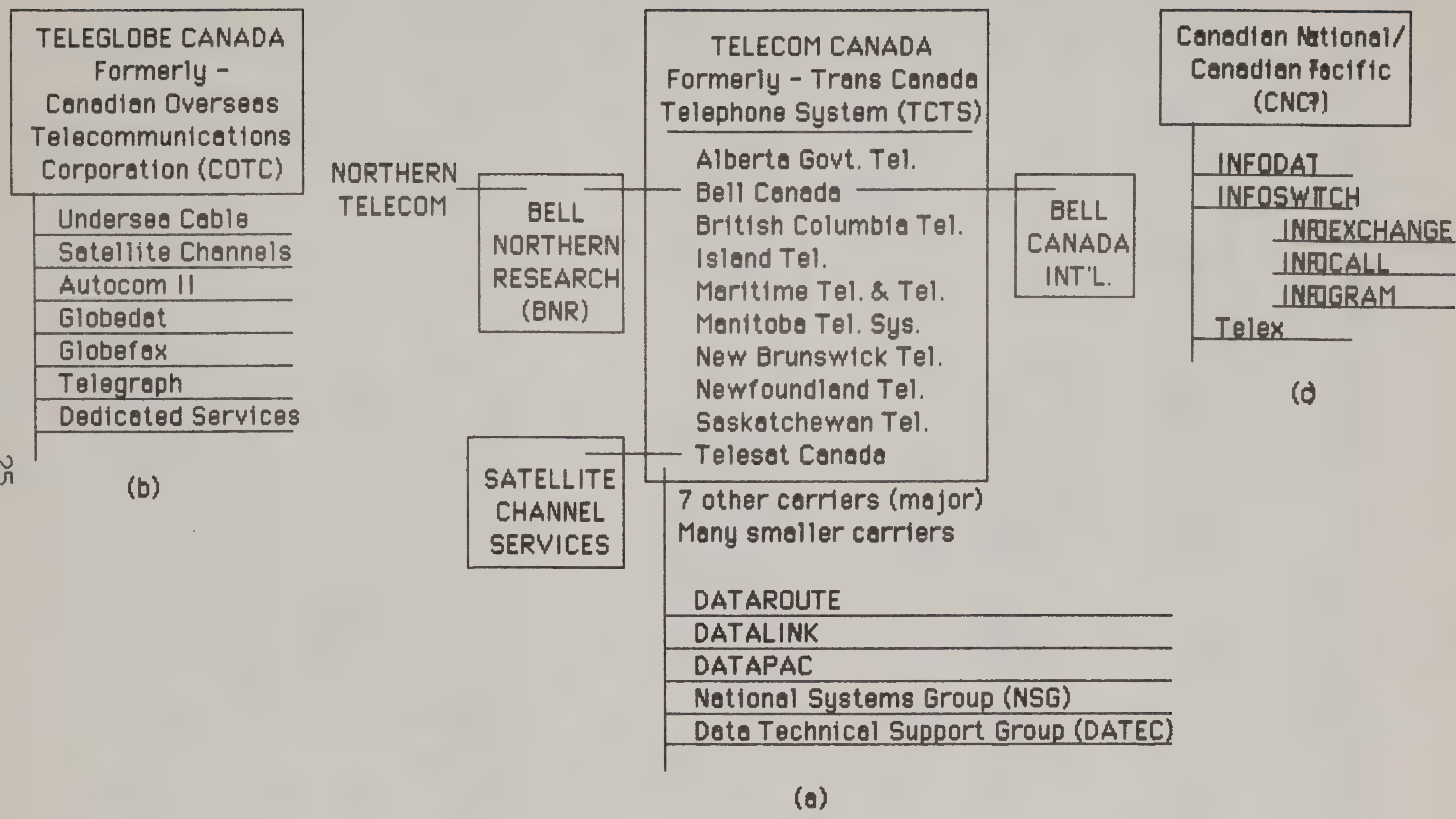
The diagram shows the major carriers that are part of Telecom Canada, but it should be noted that there are seven other major carriers as well as many smaller carriers throughout Canada that provide the various services to end users.

The largest member of Telecom Canada is Bell Canada which today is a privately owned company. Bell Canada services Ontario, Quebec, Northwest Territories, and various exchanges in the Arctic.

In a related area, Bell created a manufacturing subsidiary in 1882 called Northern Electric and Manufacturing Company to produce telephone equipment for Canadian use. Northern Electric became a separate company in 1895 and in 1976 was renamed Northern Telecom. Northern Telecom was the equivalent to the Western Electric Company in the United States which is today a part of AT&T Technologies Group.

To support research and development in the Data Communications area Bell Canada and Northern Telecom set up a separate organization which is known as Bell Northern Research (BNR). Which is the equivalent of AT&T Bell Laboratories of the U.S. It is the largest industrial research and development laboratory in Canada and they have a subsidiary in the United States which is called BNR, Inc.

Another organization that was formed by Bell Canada is Bell Canada International (BCI). This organization provides consulting services to organizations which require communications capabilities around the world.



CANADIAN CARRIERS

Figure C-1

From a service point of view Telecom Canada offers various services to the communications users. They are –

DATAROUTE –

DATAROUTE is an all digital, dedicated communications capability serving the entire country. Digital transmission speeds can range from 45 kbps to 56 kbps with either half or full duplex circuits. Point to point and multipoint circuits are available in more than 75 cities in Canada.

In areas that are not served directly by DATAROUTE facilities, users can access the service through dial-up circuits or through existing analog facilities. It should be noted however that the advantages of digital transmission lower error rates are significantly reduced when accessed through analog facilities.

DATAROUTE has a connection to the AT&T equivalent service called Dataphone Digital Service (DDS). This is called DATAROUTE International and provides all digital circuits between the U.S. and Canadian cities which have digital access capability.

DATALINK –

Datalink is a dial digital service where transmission is synchronous at speeds of 2400, 4800, and 9600 bps in a full duplex mode. Since it is bit oriented it is transparent to the user's protocol and code set. Datalink is available in all DATAROUTE locations where the user has a dedicated local loop connection to the carrier switch supporting the datalink service.

DATAPAC –

Datapac is a packet switching service utilizing the X.25 interface. It was first made available in 1977 and utilizes DATAROUTE circuits which not only provides connections all throughout Canada, but has gateways to the U.S., Europe, and the Far East. A local Datapac node can be dialed using standard analog circuits or accessed via dedicated digital circuits. The Datapac services support the following:

- Synchronous devices from 1200 to 9600 bps

- Asynchronous 110 to 1200 bps

- CCITT V.3 – ISO poll/select protocol

- IBM 2740 terminal at 134.5 bps

- IBM 3270 Bisync

– IBM Bisync HASP at 2400 to 9600 bps

– IBM Bisync terminals using contention mode up to 4800 bps

NATIONAL SYSTEMS GROUP (NSG) –

This is the organization within Telecom Canada that has the responsibility for providing all data communications services. It was called the Computer Communications Group (CCG) prior to April 1983.

DATA TECHNICAL SUPPORT GROUP (DATSG) –

This is the organization within Telecom Canada which provides personnel for assistance in designing and developing new implementations for users, and for providing assistance in solving complex network problems.

TELEGLOBE CANADA –

Teleglobe is an international common carrier which provides both voice and data services between Canada and the rest of the world. It was established as a Crown Corporation in 1950 under the name of Canadian Overseas Telecommunication Corporation (COTC). Teleglobe utilizes a network of submarine cables which cross the Atlantic and Pacific Oceans which they own jointly with other countries. Teleglobe also utilizes satellite channels which they lease from INTELSAT (International Telecommunications Satellite Organization). Specific other services that are provided by Teleglobe are –

AUTOCOM II–

This is a service which allows storage of messages for both domestic and international forwarding. Users own or lease their terminal equipment from local carriers and connect to Autocom II at speeds from 50 to 300 bps. Code conversion is provided from Baudot to ASCII for example and features a fully redundant backup system. Typical message switching capabilities such as long term storage, sequence numbering, statistical reports, line polling, and multistation addressing are also provided.

GLOBEDAT –

This is a service at which speeds of 300 to 1200 bps are common with higher speeds up to 4800 bps available to selected countries like the U.K., Japan, and France. Globedat is primarily intended to support the connection of user terminals to host computers over international circuits. The charging mechanism is based on a cost for accessing the

network, a charge based on volume of transmission (like a packet), and the duration of the call.

GLOBEFAX –

This is a high speed facsimile service for document transmission between Montreal and at present to the following countries: Australia, Bahrain, Bermuda, Hong Kong, Japan, Singapore, and Switzerland. Documents must be of standard letter or legal size.

TELEGRAPH –

This is a special leased line connection for transmission and reception of low speed teletype transmission in the speed range of 50 - 200 bps. Half and full duplex circuits can be provided.

DEDICATED SERVICES –

These are leased line services which utilize standard voice grade channels for international connections. Both satellite and submarine cable facilities can be used. It is possible to utilize these circuits for alternate voice/data services where voice conversations as well as data can be transmitted at alternate times (not at the same time). If required, wide band services can also be provided. Asynchronous data transmissions can be 300, 600, or 1200 bps, while synchronous transmissions can be up to 9600 bps. The wide band circuits can support data at 56,000 bps.

CNCP TELECOMMUNICATIONS –

CNCP (Canadian National/Canadian Pacific) Telecommunications is a joint venture of the two large Canadian railroads, Canadian National and Canadian Pacific. It is a common carrier which provides data oriented services throughout Canada. CNCP services compete directly with Telecom Canada services and also provides voice service to the Northwest Territories, the Yukon, the northern parts of British Columbia, and parts of Newfoundland. The services offered by CNCP are –

INFODAT –

In competition to Telecom Canada's DATAROUTE service, CNCP introduced their all digital transmission service called INFODAT in 1973. Transmission speeds of up to 56 kbps with point to point or multipoint capability is provided to the following cities at the present: Brampton, Brandon, Calgary, Clarkson, Edmonton, Halifax, Hamilton, Kingston, Kitchener, Lethbridge, London, Moncton, Montreal, Oakville, Oshawa, Ottowa, Quebec City, Regina, St. John, Sarnia, Saskatoon, Sudbury, Thompson, Thunder Bay, Toronto, Vancouver, Victoria, Windser, and Winnipeg.

INFOSWITCH –

This is a nationwide digital packet switching service which was introduced in 1977. INFOSWITCH provides three separate services which are –

INFOEXCHANGE –

This is a service which allows users to connect standard terminal equipments utilizing RS-232 interfaces and ASCII, BCD or EBCDIC code sets. This is a circuit switched type connection where the address of the destination is specified in an originating message, and once connected the user has a dedicated point to point connection with the addressed location. Asynchronous transmission speeds supported are 110, 134.5, 300, 600, and 1200 bps, while 1200, 2400, 4800, and 9600 bps can be supported when running synchronously. Typical of the synchronous protocols supported are HDLC (International High Level Data Link Control) - SDLC (the IBM subset of HDLC), and Bisync.

INFOCALL –

Infocall provides the ability for users to connect existing terminal equipments which utilize various standard protocols such as Bisync, SDLC, and HDLC utilizing the same speed and code sets as are utilized with INFOEXCHANGE. When user data arrives at the network location it is put into a packet format and transmitted through the network as a packet transmission. The packet sizes are established in asynchronous transmission based on either quantity of characters or receipt of a line feed character, while in synchronous transmission an entire block or predetermined packet size is sent.

INFOGRAM –

This service is very similar to INFOCALL except that the user's terminal controller must be capable of utilizing the INFOGRAM Network Access Protocol which is also known as the INFOSWITCH Protocol.

TELEX –

This is a service which provides connection to the international telex network which is the largest communication system in the world consisting of over 500,000 terminals. In Canada alone there are over 42,000 businesses which utilize telex while in the U.S. there are an additional 74,000 telex users. Telex is an international low speed message delivery service which utilizes Baudot code and transmits at a rate of 75 baud which is equivalent to 50 bps of information. It should be noted that in Baudot transmission Baud and bps cannot be used interchangably. The CNCP telex service provides a direct

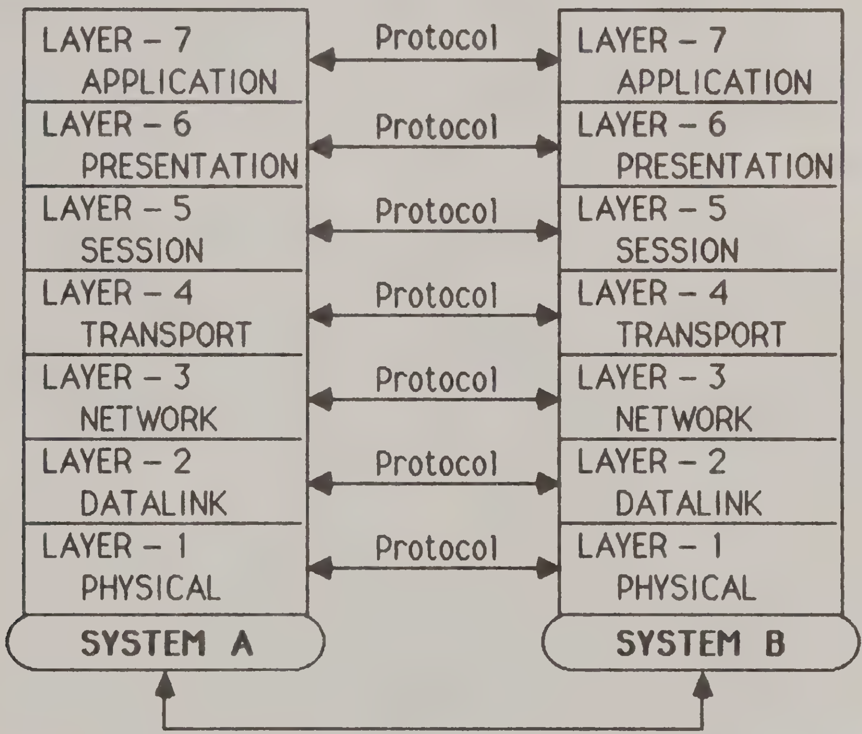
connection to the telex services of Western Union in the U.S., but does not provide a connection to the North American TWX network. In the U.S. there are conversion equipments provided by various carriers to connect the TWX and Telex networks but that is not available from CNCP. Another unique requirement of the telex service of CNCP is that only vendor provided terminal equipment can be used. Customer provided equipment is not permitted.

One last type of service to be described is provided by TELESAT CANADA. Telesat Canada was incorporated by an act of Parliament in September 1969 as a federally regulated, commercial telecommunications carrier. Even though it is not a Crown Corporation it is regulated by the government. Telesat Canada is a member of Telecom Canada and is investor owned by major carriers and the Canadian government. Until recently, Telesat operated as a "wholesaler" of domestic satellite services to other carriers only, but recently Telesat was given the option of marketing the service directly to end users as well.

The satellites used by Telesat are known as the ANIK series of which there are six presently in orbit with the seventh scheduled to be launched in 1990. ANIK is an Eskimo word for "friend".

PROTOCOLS

No discussion of the protocol world would be complete today without a description of the seven layer OSI reference model. OSI stands for Open Systems Interconnect and is a specification describing seven different layers of interface by the International Standards Organization (ISO). With all the different vendors providing all kinds of different products it is very hard for any end user to connect products and/or services that are provided by different vendors. The aim of the OSI model is to provide a standardized set of parameters which, if followed by different vendors, would provide a methodology for communicating at all levels in the user's environment. If you look at Figure D-1 you will see the seven defined levels.



OSI Reference Model

Figure D-1

On a gross level the bottom three layers, physical/datalink/network, are responsible for the communications functions and provide a mechanism for moving the information from one system to another. The middle, or transport layer, is responsible for making sure that the information is delivered from one system to another. And finally, the top three layers are processing oriented in that they involve the user's processing of the information either in anticipation of transmission or after reception. A description of each layer is as follows:

LAYER 1 – This is called the physical layer and includes the functions required to activate, maintain, and deactivate the physical connection. It defines both the functional and procedural characteristics of the interface to the physical circuit. Included in this layer are the electrical specifications, the cabling/wiring characteristics, and a functional description of the data and control flow across a DTE/DCE interface.

LAYER 2 – This is called the Datalink layer and covers the mechanism for synchronizing and error control of the information transmitted over the physical link, regardless of what that information represents. It includes error checking, acknowledgment at the receive end, and control of the data flow into and out of the nodes on a particular link.

LAYER 3 – This is the network layer which provides the necessary switching and routing functions required to establish, maintain, and terminate any switched connections between the transmitting and receiving locations. It specifies the interface of the user DTE into a packet switched network and includes disassembly, reassembly, and error correction for the various segments transmitted through the network.

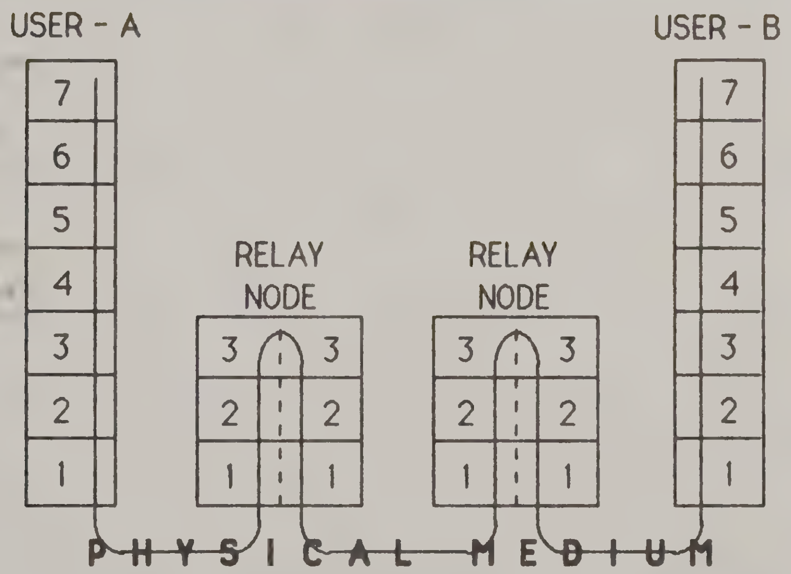
LAYER 4 – The transport layer provides an end to end control for information interchange at the reliability and quality level required for the upper three layers (the application process). This layer includes such functions as multiplexing independent message strings over a single connection when required, segmenting data into appropriate sized units for handling by the network layer, and provides a level of isolation designed to keep the user independent of the physical and operational functions of the network itself.

LAYER 5 – This session layer provides the necessary interface to support the dialog between two separate applications and provides two primary forms of dialog. The first being a two way alternating or half duplex mode, and secondly a two way simultaneous (full duplex) mode. The functions that can be performed at this level are typically setting up synchronization points for intermediate checking and recovery of file transfers, providing abort and restarts, and priority data flows.

LAYER 6 – This is the presentation layer and insures that information is delivered in a form that the receiving system can understand and use, in other words, the syntax, or the physical representation of the data. This layer is not concerned with the meaning of the information, only to present it in a form that will be recognizable by the application layer. An example of the implementation of this level is to have two terminals talking to each other where one would use ASCII code and the other one would use EBCDIC in an IBM environment. The presentation layer would provide the negotiation and determination as to which end would do the translating of the code to the application layer while maintaining the meaning of the information the same.

LAYER 7 – The application layer is concerned with the support of the end user's application. At this level the meaning of the information is important, and its function is to support distributed applications as well as to manipulate information. This means it can provide file transfers, virtual files and terminals, distributed processing, and other functions.

When two compatible systems are communicating with each other it is the two application layers that need to move the information back and forth. If there was a direct connection between the two, the information would move down in the application layer through the physical layer at that site, across the communications link and then up the seven layers in the receiving site. If however there are relay nodes involved because the connection between locations A and B cannot be made directly, the information in those relay nodes only goes up into the third layer (Network) so that determination of routing can be made. An example of this process is shown in figure D-2.



Message Relay
Figure D-2

Some of the standards for the different layers have already been established and are in common use today, especially at the lower levels. As can be seen from the Diagram in Figure D-3 at the lowest levels we have the physical interfaces such as RS-232 and CCITT X.21. The IEEE 802.3/.4/.5 are included because they meet the requirements for the physical connection of the OSI standard.

Level			
7	Electronic Mail File Transfers Virtual Terminals CAD/CAM		Process Control Robotics Graphics Document Exchange
6	ASCII Data for specific Applications - FAX/Graphics/etc. ISO 8824	EBDIC	Binary Stream ISO 8825
5	ISO 8326		ISO 8327
4	ISO 8072 ISO INTERNET 8473		ISO 8073
3	ISO 8348	ISO 8473	X.25
2	IEEE 802.2 (LLC) ISO 8802		HDLC
1	IEEE 802.3/.4/.5 RS232	 RS449	CCITT X.21 ISO 8802/3/4

Layer Specs & Descriptions

Figure D-3

At the second level the set of protocols that provide this link are HDLC (High Level Data Link Control) which is used for packet networks, for which many subsets have been defined such as SDLC from IBM. At this level there are options allowing multilink communications or splitting a single communication across multiple physical channels. This level of control is connection oriented, connectionless, and single frame transmission. What connection oriented service means is that a connection must be established between the two end systems before initiation of communications. The connection can be a physical one (actual wires) or a virtual one (predetermined routes through which packets will be moved from end to end on possibly different circuits). This is like making a telephone call where the circuit is established when you dial and then a conversation can take place over the two parties connected. The path may be different each time you dial.

A connectionless service involves transmission of data in a packet form where each packet travels independently. The path may be established on an end to end basis with nodes in between on a predetermined basis, or each node can determine the next path to take when a packet enters that node. This is like mailing a letter which will be moved to its destination regardless of any other letters sent to the same location, regardless of which route is taken.

In single frame transmission only a single frame is sent at a time.

Data Link layer protocols may have the ability to break up data into separate frames which are transmitted one at a time in order. Individual frames may require acknowledgment after receipt. If an acknowledgment is not received the packet will be retransmitted. In this way the Data Link layer provides packet flow control which in turn will allow the system to change speeds at either end.

With regard to the network layer, its primary functions will include network connections, data transfer, reset, and connection release type functions. This is in conformance with the X.25 standard and the separate ISO standard #8348. At this level there can be many different types of networks. Therefore each family of protocols which are developed for use within this layer will have a unique identifier so that it can be identified and changed if necessary during the transmission of a message if required.

At the transport layer ISO spec #8073 specifies multiple classes of protocols for connection oriented communications, while ISO #8072 specifies the types of service which must be provided at this level. Typically, Layer 4 protocols validate that data is not modified, duplicated, or lost in transmission. It also includes end to end error checking, or it can pass on the validation which may be provided in the network layer.

At the fifth level ISO #8326 specifies the type of service and ISO #8327 specifies the protocol. There is still alot of work being performed at this level of specification, but it will contain two separate subsets of service. First will be the session kernel for establishing and releasing a session while the second will be token management which is a request for use of resources that is added to the kernel.

At the sixth layer ISO #8824 has been adopted which provides rules for defining and recording the meaning of individual messages. In conjunction with this are basic encoding rules which are defined by ISO #8825. These are rules to convert notation type descriptions into actual messages for subsequent transfer.

As the top layer, the application layer involves the actual user application itself and includes the functions required for transfering files, accessing information, transfering jobs, manipulating data, message handling, virtual capabilities, and others. The application layer is normally oriented towards a particular type of business such as banking, automation, and electronic mail.

Functionally, a message is generated at the user's application and is inserted at the seventh layer. The application level adds a header identifying the appropriate parameters and sends it down to the sixth layer which puts its own header on. This continues with each level adding its own information on to the length of the message until it reaches layer two where it is put in a packet form with an X.25 transmission frame. The physical layer sends out a series of bits, and at the receiving end each individual piece of the header is stripped off as the information works its way back up

the ladder. Finally, the user's application at location B can look at the message in a form that can be directly utilized by the user at that location.

Many people have found it hard to conceptualize this multiple layering of transmissions with each layer providing its own unique function. A good analogy to use to describe this for the functions involved is to describe the generation and transmission of a letter between two locations where the language spoken is different, such as the United States and Japan. Let us assume that a Japanese factory manager has read about a new product being manufactured in the United States, and he would like to obtain manufacturing rights for his company. The need for information is the application process which will generate a need for information to be obtained. The manager goes to one of his engineers who becomes the application layer in that the engineer will prepare the appropriate questions to be asked in the letter, especially about the technical aspects of the product. The engineer then gives the questions to a translater who will prepare the actual letter in English so that it not only utilizes the correct format but also provides the specific questions in English which will provide the information asked for by the Japanese engineer. This letter is typed in English which is a language common to both the transmitter and receiver. After typing the letter the translater gives the letter to a secretary who represents the session layer. The secretary makes a copy of the letter and validates the correct name and address of the recipient. At the same time she puts a copy of the letter in the New Product Request file. The secretary then brings the letter down to the mailroom manager who represents the SESSION [redacted] layer. His job is to guarantee receipt of the letter in the U.S. He does this by first making a copy of the letter and then selecting the best path by which to send the letter which is accomplished by originally approving the physical connection and then providing a mechanism for validating receipt of delivery. He assigns a sequencing number to the letter which will identify it as the only part of this particular transmission and then sends it on to a shipping clerk who must establish the specific route over which the letter will be sent to the U.S. The shipping clerk is the network layer. He will pick the appropriate path and inform the mailroom manager of what that path will be.

The shipping clerk decides that the best way to send the letter is to send it airmail to the company office in the city where the recipient company is and then have one of their employees hand carry it over to the company. This path was chosen especially to show both public and private facilities which could be used in conjunction with each other. The public service is the mail while the private service is the hand delivery by one of the company employees. The letter is then sent to the the packaging department which is the datalink layer. The packaging department makes a copy of the letter, puts the letter in a bag with other letters addressed to the U.S., and counts the letters in the bag. The count is then put on the package as a tag. The bag is then moved to the shipping dock which represents the physical layer, or interface to the physical medium through which the information will be carried. Regardless of the method of carriage (truck, plane, train, etc.), the message is now transmitted.

When the bag arrives in the U.S. the workers on the loading dock of the company will move the mailbag to the mailroom and count the letters in the bag. If the count of the letters in the bag does not match the count on the tag, the entire bag is determined to be invalid (because the specific letter missing is not known), and the mailroom in Japan is notified to send a copy of all the letters that were originally in that bag using the copies kept at the shipping end.

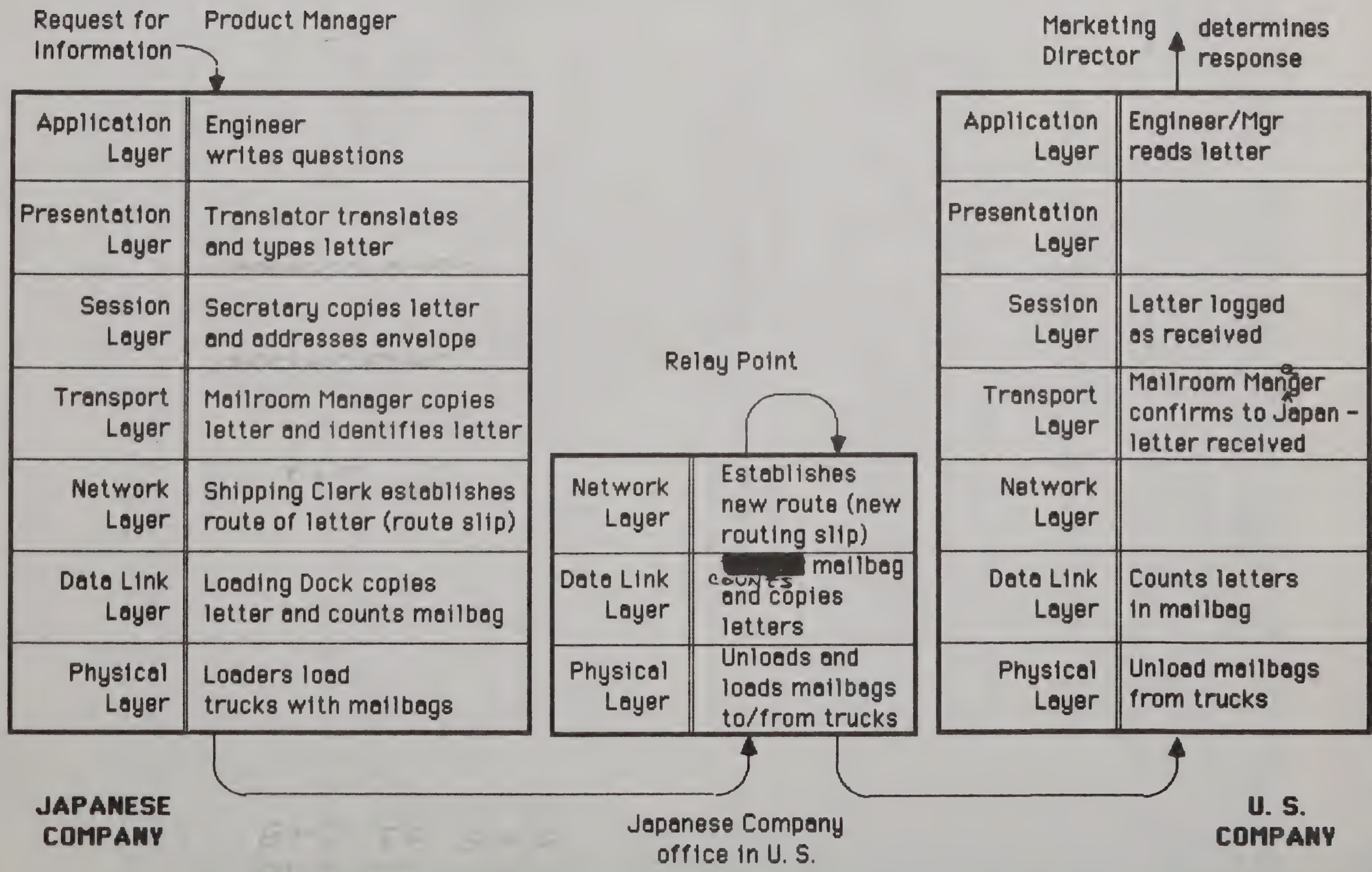
This process is analogous to the "frame check sequence" which is performed by the Data Link layer.

Once the mailbag has been validated as to receipt of all letters, the letters can be delivered to the appropriate people. In the case of the letter to be hand delivered it is brought to the company courier who will then hand carry the letter directly to the company who is manufacturing the product in the U.S. Delivery is made to the appropriate executive who then will read the message to determine what kind of answer will be forthcoming, and the process starts over again in the opposite direction. This process is shown in Figure D-4.

There have been reams and reams of additional descriptions and explanations of the OSI model, especially as it applies to packet switching [redacted], and in addition there have been other protocols which are based on the OSI, some of which will be described here.

MAP/TOP

Directly related to the OSI model, and at the same time a subject of very hot debate today, is the Manufacturing Automation Protocol and Technical and Office Protocol (MAP/TOP). MAP has been pushed very heavily by General Motors Corporation since 1980 in an effort to automate the factory floor. In order to tie together computers, terminals, robots, management functions, etc., a common form of communications was needed because the various products were built by different vendors. In order for all of them to talk together to accomplish the automated factory floor, General Motors decided to encourage the use of a standardized interface which evolved into MAP. In order to keep as much compatibility as possible throughout the world it was decided to utilize the OSI reference model as a base for the MAP protocol.



OSI Example
Figure D-4

<table>
<tr><th>LAYER</th><th>TOP VERSION 1.0
PROTOCOLS</th><th>MAP VERSION 2.1
PROTOCOLS</th></tr>
<tr><td>7</td><td>ISO FTAM 8571
File Transfer
Limited File Management
~~ASCII and Binary Data Only~~</td><td>ISO FTAM 8571
File Transfer Protocol*
Manufacturing Msg. Format Std. (MMFS)
Common App. Service Elements (CASE)
ISO 8649</td></tr>
<tr><td>6</td><td colspan="2">Null – Using ASCII and Binary Data Only</td></tr>
<tr><td>5</td><td colspan="2">ISO 8327 – Session Kernel – Full Duplex</td></tr>
<tr><td>4</td><td colspan="2">ISO 8073 – Transport Class 4</td></tr>
<tr><td>3</td><td colspan="2">ISO INTERNET 8473 – Connectionless
X.25 – Subnetwork Dependent Convergence
Protocol (SNDCP)</td></tr>
<tr><td>2</td><td colspan="2">ISO 8802/3 – Logical Link Control (LLC)
IEEE 802.2 Type I Class I</td></tr>
<tr><td>1</td><td>ISO CSMA/CD 8802/3
IEEE 802.3</td><td>ISO Token Passing Bus 8802/4
IEEE 802.4</td></tr>
</table>

* File Transfer Access Method

MAP / TOP MODEL

Figure D-5

As an outgrowth of the MAP project, the Boeing Corporation has been urging the use of the TOP protocol for office environments. Because the two environments are oriented towards different functions and have different requirements they are complimentary but are not exactly the same. One of the primary areas of difference is in the lower levels of OSI where, because of time constraints, MAP utilizes a token passing scheme to guarantee access by all devices on the bus connection, while TOP utilizes a CSMA/CD or Collision Detection mode of information transfer. There are also differences at the top or application level which are unique to both areas of implementation. A comparison of the two protocols is shown in Figure D-5.

As can be seen Layers 2-6 are the same for both the protocols. At the physical layer (Layer 1) IEEE 802.3 was selected for TOP for the primary reason of ease of conversion between TOP and ETHERNET type Baseband networks, which are predominantly used in office environments for moving files and messages and priority is not critical. MAP on the other hand uses IEEE 802.4 which is the token passing scheme that guarantees priorities and maximum calculable delays between times that a device will have access to the bus. At the top level TOP uses primarily file transfer and limited file management capabilities while MAP uses a series of application oriented protocols like MMFS and CASE. These latter two protocols are also ISO standards but are not necessary for use within TOP.

At Layer 6 (presentation) the protocols list a "null" as that level protocol. In actuality nothing takes place at this level from a functional point of view because the application level already uses binary or ASCII code in all locations, making the need for conversion unnecessary. Layer 6 is kept in the diagram so as to maintain conformance with the OSI model. All it really means is that there is no change in the form of the information between Level 5 and Level 7.

There has been a considerable amount of documentation and meetings taking place regarding both of these protocols with the tendency of some of the larger companies to go with MAP for their factories, Chrysler being a notable exception at the moment. The economic impact of the larger corporations pushing MAP especially will probably mean that vendors will come out with MAP compatible products because they obviously would like to sell into that market. TOP, being newer (1985), still does not have the economic push, but it seems that many user organizations are also looking at long term compatibility between office products and are therefore beginning to look for conformance to some standardized communications interface.

Diagram D-5 shows the 2.1 version of MAP, but there is a newer version called 3.0 which is expected out momentarily which is expected to incorporate some changes at the application level. The big change that is expected is in FTAM (File Transfer Access Method) where under MAP 2.1 two different file structures are supported, while in 3.0 it is expected that five different file structures will be supported. This points out an area of potential danger for implementors of both MAP and TOP, that is the continuing evolution of the standards. It would be quite possible to implement a system on a particular level version of MAP or TOP and then find out within a short period of time that the new version of the spec has an upgraded or more defined level of definition for one of the layers which might cause an existing system to be incompatible without the capability of being upgraded. It is for that reason that Chrysler Corporation decided not to use MAP in some of their recent factory installations. They have not said they will not use MAP, they only said it was too early to make a final commitment.

There are user's groups that meet on a continuous basis, and if a potential user is interested in a potential use of MAP or TOP they should join one of these groups to find

out the latest information and make their own decision regarding whether to implement them or not.

IBM ACTIVITIES

As the end user well knows IBM has usually taken their own path when developing new products and services. This is especially evident in the communications world with the evolution of System Network Architecture (SNA) which was first announced in 1974. SNA is a comparable architecture to the OSI model, but it is not compatible, and for many years IBM has purposely kept them apart. More recently however an organization has been formed in the U.S. called the Corporation for Open Systems (COS), and although IBM was not one of the charter members, they have subsequently decided to join. Today there are more than forty of the largest companies in the United States as part of COS and their charter is to provide for the introduction of interoperable, multivendor products and services operating under OSI/ISDN/ and other international standards. Also within their charter is to develop the necessary test standards to validate that new products do meet the specific standards required. At the moment COS would like a certification program, and they are in the process of trying to formulate the ground rules for it. Because standards are not true standards unless agreed to by all potential users, COS is trying to work with SPAG in Europe and Sigma in Japan while working for the same objectives in those geographic areas. Apparently, IBM feels that there is a tremendous market in the world for additional products and services, so rather than fight everybody else, they have joined, but in all likelihood, they will push for standards which are closer to their own developed standards at each level where applicable.

Also in the IBM world there are a whole series of new offerings which indicate IBM's evolutionary path towards communicating between multiple diverse products of their own. Listed below are some of the key products in that environment.

DCA – Document Content Architecture – This defines a uniform method for describing the content of a document with respect to formatting that includes headings, centering, highlighting, and pagination. Documents in DCA can be in either draft or final form. DCA describes the content of the document itself, and it usually used in conjunction with the next program called DIA.

DIA – Document Interchange Architecture – This allows the interchange of documents or information across a network in either a draft or final form. When utilized with DCA, DIA is analogous to the envelope in which the DCA document is to be sent. Transmission is allowed to multiple destinations and there is also an access to DISOSS provided.

DISOSS – Distributed Office Support System – This is an application program that normally resides in a host processor. It provides for the storage, retrieval,

and distribution of documents created by IBM products which have APPC (see next paragraph). Typical examples of DISOSS software are the 5520 Administrative System, Scan Master One, and Display Writer.

APPC – Advanced Program to Program Communications – This software provides for what is known as Peer to Peer Communications at a remote terminal level. Whereas the SNA world is hierarchical and defines structures, formats, rules, controls, operator requirements, and management for control of sending data in the network, APPC allows terminals to talk directly to each other. Work stations will no longer need to emulate a 3270 terminal. In the SNA environment there are two important definitions. Logical Units (LU) represent users which are either people or a specific application program, while Physical Units (PU) represent the network communication devices and are called Nodes. PU 2.0, for example, describes a cluster controller such as a 3274 or 3276 and also a batch terminal like a 3770 while PU 1.0 describes an individual device like a video display or printer.

The current version of these packages is [redacted] contained in LU 6.2 where two devices can communicate with each other directly [redacted] and either one can initiate a session. This is different than SNA where the initiation of a communication is the responsibility of the primary LU (SNA is hierarchical). PU 2.1 is the version utilized here which connects a node to a mainframe.

The standardized interface to a SNA network is called a Protocol Boundary which is rigidly defined in LU 6.2 and it is called an Application Program Interface (API). This will allow LU 6.2 to be product independent.

By using LU 6.2 with the PU 2.1 subset intelligent work stations can communicate with each other instead of going through the hierarchical path which was previously required under SNA. The users are linked through what are called LU to LU "sessions".

APPN – Application to Application Networking – This is a description of a process which is one level up from APPC in that it divides the SNA network into two classes of network nodes. The Subarea Nodes are SNA hosts or 3720 communications controllers. They are statically defined by tables within each Subarea Node and are established one time by an operator. The peripheral nodes do not participate in any intermediate routing processes and are typified by a 3274 controller, System 36, or a PC. These peripheral nodes can be dynamically reconfigured by updating the tables in all the nodes when a new peripheral node is added. This will be done through enhancements to LU 6.2 and PU 2.1.

In coming up with the development of LU 6.2 IBM tried to have LU 6.2 defined as the presentation layer of the OSI model, but this was defeated. Still because of the huge market for IBM equipments, in all probability there will be many LU 6.2 compatible devices being built by other vendors as well as standard OSI compatible devices.

SNADS – System Network Architecture Distribution System – SNADS provides the capability for non-real time delivery of information between users. This means you can generate a document for transmission which can be sent into the network through SNADS and the intended recipient does not have to be active at that time. SNADS will deliver the document later. This is much like a messaging system, and it is very much like CCITT Spec X.400. If DCA is equivalent to the letter, DIA equivalent to the envelope, then SNADS is equivalent to the mailman.

CCITT X.400 – This is a messaging protocol which is equivalent to the seventh layer in the OSI model. Although not an IBM product, IBM did demo an X.400 gateway to what they called Profs (Professional Office Systems). X.400 was issued in 1984 as a mechanism for integrating voice, data, and imaging messages across diverse networks. The primary application for this is electronic mail. As an upgrade to electronic mail, which is not used as often as desired because of the diversity of message types, X.400 provides the necessary standard to allow interchange of messages between different kinds of networks.

X.400 incorporates "Suites" or "Groups" of protocols to provide internetwork compatibility at different levels. This includes the message composition, format, envelope, and addressing. It operates at the sixth and seventh levels of the OSI model (presentation and application layers). It is being supported by more than forty of the large equipment vendors especially DEC and COS also. To make the X.400 implementable without too many options it is a very rigidly defined spec. Software to support this is expected in 1987 although DEC says they have an X.400 compatible device today.

While talking about X.400 it should be mentioned that CCITT X.200 is their formal adoption of the OSI model.

Profs – Professional Office Systems – This is both a text and management support system for host VM operating system software. It provides for the interface between office systems and a host processor.

STANDARDS

One of the questions that comes up very often regarding the use of different protocols is what standard do they meet and are they interchangeable. Typically, they are not interchangeable but they can be described as belonging to one of three primary categories of protocols. They are character control, character count, and bit oriented protocols. Listed in Figure D-6 are the standards established by the different standards setting organizations. ECMI is the European Computer Manufacturer's Association while the others are self-evident.

CHARACTER CONTROL	CHARACTER COUNT	BIT ORIENTED
ANSI X.3.28	DEC DDCMP	ANSI X.3.66 (ADCCP)
ISO 1745/2111/2628 2629 Basic Mode		ISO 3309/4335/6159 6256 (HDLC)
ECMA 16/24/26/27/ 28/29/37		CCITT X.25 LAP/LAP B/ X.75 LINK LEVEL
IATA SLC		ECMA 40/49/60/61/ 72 (HDLC)
IBM Bisync		U.S. Gov't. Fed Std. 1003A FIPS 71
		IBM SDLC
		Burroughs BDLC
		Univac UDLC

PROTOCOL STANDARDS

Figure D-6

FLOW CONTROL PROTOCOLS

A type of protocol that was left out of the original text, and one which is getting a lot of use now in the PC world is the flow control protocol. These consist primarily of low speed asynchronous type communications between PC's and peripherals, but is also

applicable when terminals are talking to computers. What flow control means is to allow transmission on a continuous basis until specifically told not to transmit any more. One of the most common of these is the so called "X ON/X OFF" protocol. This is also known as an inband protocol because an ASCII character is used to define the X ON and X OFF functions. An X ON character is sent by a device to let another device know that it can accept data at any time. The X OFF is sent when data can no longer be accepted. Typically this is the sequence of events in a terminal to a printer communication where the printer sends an X ON when it can receive data in its buffer and an X OFF when the buffer is filled. This cycle continues until the entire message is sent.

A second form of flow control protocol is called DTR ON or DTR Protocol. DTR is a signal at the RS-232 interface and is the Data Terminal Ready signal. When the DTR signal is high it means that the device can accept information. When the DTR signal is off, it means that the device can no longer accept information. This can operate the same way as X ON and X OFF in that as a buffer is filling in a printer the DTR can be high, and as soon as the buffer gets full, the DTR signal can be turned off.

A third form of flow control protocol is called the ETX/ACK which is an acronym for End of Text/Acknowledge. The ETX/ACK is also similar to X ON/X OFF in that it is a software type flow control. In this case the data must be sent in a block of a predetermined length which is defined based on the size of the buffer in the device to which information is being sent. A block is sent in the predefined length, and then an ACK must be returned by that device before another block of the same length can be sent. The block is sent with an ETX character at the end regardless of the length, as long as that length does not exceed the buffer size. The transmitting device will then not send any additional data until the recipient sends an ACK character back.

PC PROTOCOLS

The majority of PC interfaces to the communications network have been low speed asynchronous TTY compatible like protocols direct to a device that could communicate utilizing the same protocol. TTY protocols have serious limitations in that they cannot tolerate line turnarounds, and therefore must be used with full duplex modems. In addition they have no method of error detection and correction. As such the majority of PC communications have to be validated either by applications software or the operator who is both entering and receiving information. This is obviously a very dangerous way to transmit information if you are moving files from one location to another without operator intervention.

In response to the limitation of not being able to check for errors, some vendors have written separate software packagees to be utilized by both ends of the circuit, while at the same time, some modem vendors have come out with a methodology for transmitting and receiving transmissions, detecting errors, and then retransmitting a block of data in

the event that block was received with an error on the previous transmission. There are really two different kinds of protocols and they are described below.

X.PC – This is a public domain protocol which is receiving enthusiastic support from TYMNET. It is excellent for use in communicating with the packet network, in that the transmissions to and from the end user to the packet will be validated, and you don't have to wait for the host CPU to reject a transmission before you find out something was entered wrong. This is a very efficient protocol that allows two way file transfers.

MNP (Microcom Networking Protocol) – Until recently this was a proprietary protocol but is now available for a $100 documentation fee. It is efficient for two way file transfers but does not support multisessions as X.PC does. MNP and X.PC are at present vieing for which will be the most used PC protocol.

X MODEM – This is a public domain protocol which is relatively inefficient and provides for one way file transfers only. X MODEM cannot be used in an unattended mode.

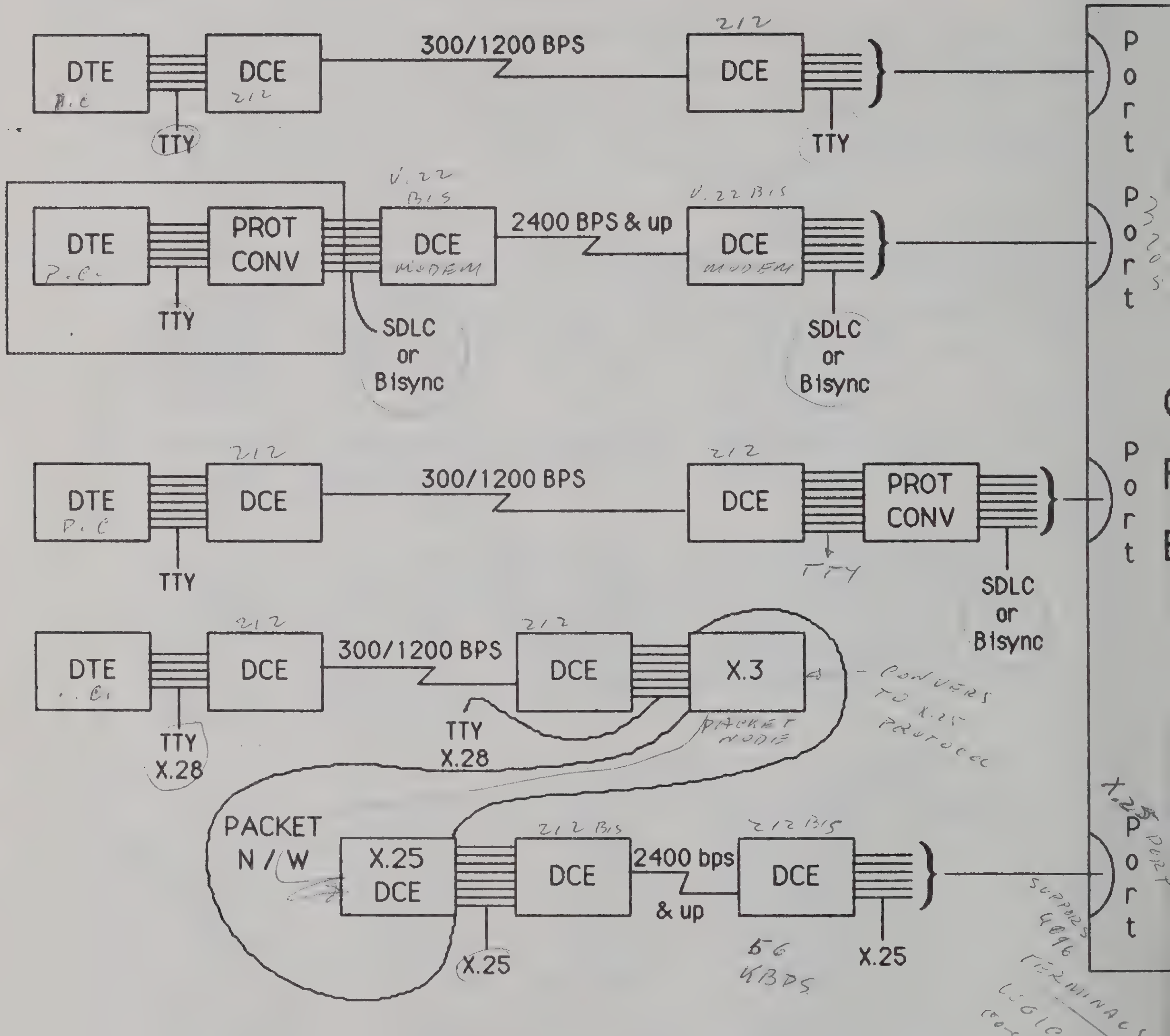
BLAST – Blocked Asynchronous Transmission – This requires software at both ends of the connection where the transmission can be in a virtual file format. BLAST is proprietary and with its limited usage to date it is not likely to become a standard in the future, even though it is very efficient for two way file transfers and provides support for most PC's and Mini's. BLAST is supported TELENET.

Kermit – This is a public domain software package that allows one way file transfers. Although not widely used, it enjoys the enthusiastic support from those individuals who do use it.

Typical Prices for Value-Added Network Services

Network	Traffic Charges	Asynch Terminal Connect Charges: Dial-up	Asynch Terminal Connect Charges: Private	Synchronous Host Access Charges
Telenet	First 1500 packets included in dial-up fee, then $1.70 per 1000	$6.04–$13.91 per hour. also in minutes	$500 for installation $290-$750 per month, depends on location and facility	$400 for installation $800-$1100 per month Depends on number of ports
Tymnet	$.01-$.05 per 1000 characters Depends on time of day	$2-$11.25 per hour Depends on location and time	$500 for installation $250-$450 per month, depends on location	$750 for installation $300-$600 per port per month
Uninet	$.01-$.05 per 1000 characters Depends on amount of traffic	$1.10–$3.50 per hour Depends on location and time	$500 for installation $225-$425 per month, depends on location	$500 for installation $900 per port per month
Autonet	$.03 per 1000 characters	$3-$4 depends on speed	$500 for installation $250-$275 per month, depends on speed	$1000 for installation $1800-$3000 per month depends on number of ports

Valid - June 1986



Protocol Conversion

P.C. WORLD